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THE CONSERVATION OF WATER RESOURCES.

BY M. O. LEIGHTON, CHIEF HYDROGRAPHER, U. S. GEOLOGICAL SURVEY, WASHINGTON, D.C.

[*Read September 23, 1908.*]

It is extremely difficult, if not impossible, to confine the presentation of this subject to those features relating solely to municipal water works. It is so broad and comprehensive that it does not admit of separation into parts, but each field of application comprehends every other. One, and only one, great problem is involved in the conservation of water resources, and when we attempt to separate the particular province of irrigation from that of flood control, or the field of municipal supply from that of water power, or attempt to legislate, to contrive, or to construct for the benefit of one interest exclusively, we often find that we have wrought to the disadvantage of every other. Every detail in the conservation of water for city supply, for example, should be weighed and considered, not exclusively from the single viewpoint, but with due regard for all allied problems of water utilization. The final wise course to be pursued will be that which will serve the greatest number of objects in the wisest way.

We have made little, if any, progress toward the final development of our river systems. Certain improvements have been made, here and there, directed toward a particular and immediate purpose, such as the creation of a navigable channel or the storage of a municipal supply. Beyond this conditions are chaotic, and mature consideration of the matter will show that the principal reason is, that we have, during past years, endeavored to provide

specifically for one interest to the exclusion of another. What, indeed, has been our practice in the development of rivers for navigation? Our engineers have endeavored to provide channels of stated depth at low-water seasons. No other purpose has been confessed. Our water-supply engineers have endeavored to secure storage capacity sufficient to supply municipalities with all the water required, whether the season's drought be long or short. No other purpose have they had in view. Our water-power engineers have endeavored to so develop certain selected sites that they might be made to produce the greatest amount of available energy, and they have thought of little else. Now, in connection with these several developments, had there been foremost in view the ultimate maximum development of the whole river system for present and immediate uses, as well as for those that are bound to come in the far distant future, there must have been an harmonizing of all the various interests involved, so that each step in the subjugation of the river for one or for another purpose would have become a part, so far as physically possible, of the development of the great unit problem.

In the construction of a building, we consider that each stone laid in the wall is not merely a necessary part of the wall at that immediate point, but is a progressive feature of the whole structure, performing its part in the support of the building, and harmonizing itself with the entire plan. So should be each feature of the development of our water resources, and when this is realized and put into practice, we may consider that we have gone a long way toward the final solution of our problems.

It will now be profitable to consider just what we mean by the water resources of the United States. The first impression conveyed is that of a certain amount of water collected on certain drainage basins and conveyed through certain channels into the ocean, and being made to perform, in transit, certain work of benefit to the people. This is not all. Water is not a resource unless it is available for use, and the conditions under which it is so available determine the amount of resource represented. If the water resources of this country are locked up under conditions of ownership or rental which make them either unavailable, or available only at high cost, the resource represented is far less than would

appear upon first consideration. Therefore, we have to consider the condition of ownership and policy of treatment and retention as well as the amount of water and its potential possibilities.

This matter of ownership is one in which we can hardly find cause for congratulation. The United States was abundantly provided with water resources before the American people set foot on the continent. Therefore, we can gain no credit from the actual possession. We begin to be concerned when we consider our stewardship or our administration of those resources, and just there, at the first point where we must be tested, we begin to fail. It appears that we have omitted no expedient by which they could be wasted and placed beyond our control. We find in the third annual report of the New York State Water Supply Commission the following melancholy statement: "We have only to look across our northern border to the Dominion of Canada to see how our mistakes in allowing private interests to acquire natural resources have been avoided by the statesmanship of the Dominion government." This admission was made by a group of gentlemen who had been at work for a year on investigations necessary to collect information relating to the water powers of the state, and to devise plans for the development of such water powers for public use under state ownership and control. This commission was guided in its work by one of our foremost engineers. The character of the work and the excellence of the report are sufficient assurance that this group of gentlemen weighed its words and we may assume that this commission took no particular gratification in admitting the conditions above quoted. What is true in New York state is also true in greater degree in all of the other states of the Union — certainly in no less degree. Therefore, when we examine our water resources for the purpose of determining upon proper public policies, we find that we are obliged to look across an international border to find that condition which we, ourselves, ought to be able to realize. We have been poor stewards. In the one feature of water conservation in which we, as a people, have absolute control, we have failed.

There are many reasons why we have been lax in our public policy and are now liable to pay the price. Not the least among these reasons is the extremely pronounced tendency of the average

American to secure the highest possible profit during the immediate moment, without regard to future consequences and to the exclusion of every civilized duty to future generations. There is something more to be considered than the present generation. All these resources are merely to be held in trust for the future. The President of the United States was right when he said, "You are a very poor citizen if your interest in general welfare does not extend beyond your own generation."

Another important reason for our lax public policy is our apparent lack of ability or willingness to exercise legislative foresight. If we review the history of water legislation during the past century we will find very few acts deliberately framed to provide for the future. We legislate as a rule "from hand to mouth." When an abuse is discovered, remedial legislation follows. When an emergency arises, acts are passed to meet it. When there is a pressing need, new laws come to the rescue. But it is nearly always evident that the emergency is at hand, the abuse past history, and the need urgent. We find very little legislation the intent of which is to provide for future contingencies, or to so remedy present practices as to avoid those contingencies. Now it happens that the conservation of water resources is not a matter that can be treated under ephemeral and emergency legislation Acts passed for this purpose must all be the result of legislative foresight. Their application to the needs of the country may be in the immediate present or generations hence. It is a far cry from such legislation to that enacted under the principles of the famous expression, "Posterity be damned." Summing up the whole matter of our present attitude, one can hardly avoid the reflection that we belong to the tribe of Esau, who for present gratification sold his birthright for a mess of pottage.

There is another reason why we have wasted our water resources. Being born of the tribe of Esau gives us wasteful tendencies, but these may be overcome, as have so many other barbaric habits. The reason why they have not been overcome is that the people as a whole have been so ignorant concerning the water resources. At the first settlement of this continent water resources were so abundant for the few people who came to these shores that there was no necessity for considering their extent. In this respect it is

extremely unfortunate that this continent was not first discovered on its western coast, for then the early settlers would have immediately been confronted with the necessity for considering the water resources. This abundance of water in the East continued to make it unnecessary to take a thought for the morrow through all the days of construction and reconstruction, and it is only within a recent period that this country has become so thickly settled that thoughtful men have deemed it wise to take an account of stock.

Probably 90 per cent. of our people know nothing of our water resources, and the remaining 10 per cent. know all too little. Here is emphasized the need of investigation. If we go back to first principles, it is clear that before we can write we must know the alphabet. Before the present day of steam propulsion came the elementary investigation of Watt and Stephenson; before the present day of electric transmission came the studies of Franklin, Gilbert, Faraday, Volta, and a host of others. The inference is obvious. Before our people can know the extent of their resources, and provide proper legislation for their development and protection, they must know our rivers, their flow, fluctuations, eccentricities, and every feature that contributes to or modifies their utilization as a natural resource. The engineering profession to-day is building great water works of various kinds and basing some of their most important calculations on empirical formulæ. They seek, for example, to determine flow, seasonal distribution, etc., by applying the data determined for one basin to supposedly similar conditions on another. There is much that is not well understood and much more that is understood by a few but has not been popularly disseminated. What, for example, does a water horse-power mean to the average man? It represents no tangible value, as does a barrel of oil or a ton of coal. Therefore, it is something easily and cheaply acquired by private interests. It is something too cheaply purchased and too profitably disbursed. Yet this average man, who knows nothing of the water resources, and to whom a million gallons of water or a thousand horse-power represent merely an indefinite figure, is the one *who shapes our legislative policies and who is responsible for the fact that we must look across an international border for our ideals in water conservation.*

I have said that the average man is responsible for the legislation, but the fact remains that we whose professions lead us into the consideration of water problems are responsible for the ignorance of that average man. We, and we alone, are the individuals who are in a position to teach concerning these matters and to provide for the proper investigations and encourage the proper legislation whereby a wise public policy may be adopted.

If we would sum up the water resources of the United States, we must begin at the sources of supply, namely, the individual drainage areas. Here are catchment basins receiving from the clouds the annual supply of rain. As the rain falls at various times and with varied intensity, so must these basins discharge the water. We have, then, a fluctuating condition, sometimes with rivers high and again with long seasons of low water. The ideal condition would be uniformity in discharge, but this can never be attained. We are not, however, prevented from approaching this ideal condition as closely as possible and, therefore, we are confronted, first of all, by the consideration of floods.

A flood is primarily a waste of water. Although we usually consider it solely as a damage to property, trade, and public comfort, its worst feature arises from the fact that it deprives us of water which might be put to useful purposes. Obviously, the way in which to arrive most nearly to the ideal condition of uniform discharge is to cut off the flood and to increase the low-water flow. Thus we may make both extremes come closer to the mean. To arrive at this end we must save the floods, place them in safe deposit where they can be drawn upon in times of water depression, just as the merchant draws upon his bank account, accumulated during prosperous business periods, at the time when he needs it in periods of financial depression. Our uplands are good for little, as a rule, except for growing of timber and the storage of water. Such uses do not interfere with the purposes of recreation which have become so important in American life, but rather enhance their value for such purposes. Therefore, it seems to the writer that the goal toward which all efforts should be directed should be that condition in which our rivers shall become effectively managed in their discharge. Thus would we not only save the water for beneficial uses, but we would effectively prevent a

large part of the losses due to our annual flood devastations, which amount easily to $100 000 000 per average year.

Having stored our floods, these waters can be released as needed for various purposes below. They can be used to supply cities, to irrigate fields, to assist in maintaining navigable depths in rivers, and, while descending to perform these services, these same waters can be made to turn power wheels for the benefit of manufacturing and commerce. The condition above described is ideal and many good men have regarded it as beyond realization. Doubt has been expressed in spite of the fact that in the few cases in which the idea has been put into practice great success has been realized. Nevertheless, the doubts of able men have prevented thorough investigation of the scheme on a large scale. It is not necessary to actually arrive at the ideal condition in order to receive benefit. There may be, by reason of engineering or natural difficulties, certain losses, certain failures to approach the condition just described, but until we have approached it as nearly as possible, we shall not have performed our work in the conservation of water, nor shall we have discharged our stewardship of this enormous resource.

Instead of conserving our flood waters, we have exercised the utmost ingenuity in increasing their violence. We have, for example, allowed the forests to be cut off and thereby increased the speed with which the precipitated water flows into the river channels. As this subject will be more thoroughly discussed in another paper at this convention, mere mention of the fact will suffice for present purposes. In our public lands we have granted water rights for a small tithe of their value, and in the majority of cases these grants have not resulted in productive development of the rights but merely tied them up, made them unavailable, and thereby assisted their speculative exploitation. By other and similar means and expedients we have established our reputation for improvidence. Unless our policies are reversed, American mankind will pay the price.

The impossibility of suitably covering a subject so great in scope as that implied in the title of this paper is already apparent. Realizing this in the beginning, the author has deemed it wise to avoid discussion of details concerning the extent and regional

distribution of water resources and to present a few thoughts with relation to general public policy. Summarily, it appears that the first step necessary in the conservation of our water resources is a distinct reversal of present public policies and conventional legislation. The second is to prosecute, with zeal, the scientific investigation of the water resources so that facts necessary to their intelligent treatment will be in hand. Third, it is necessary to disseminate broadly this information so that the average man who is responsible for our legislative policies will appreciate the necessity for reversal thereof. This is primarily the duty of engineers and water-works men. They alone possess the means of education. Finally, after the investigations have been concluded and we have at hand facts sufficient for our purposes, it will be necessary to treat the one great subject as a unit, with due regard for all the necessities imposed by the various interests of water utilization, to start our actual conservation work at the sources of supply, and there so to adjust the distribution of water that it may be made to serve in the most useful way all the needs imposed by demands of our present generation and the necessities and demands of those that shall come after.

FOREST CONSERVATION.

BY R. S. KELLOGG, ASSISTANT FORESTER, UNITED STATES FOREST SERVICE.

[*Read September 23, 1908.*]

Ours is primarily a wood-using civilization. Despite the introduction of substitutes for wood in the form of stone, cement, concrete, and steel, our consumption of timber has constantly increased from the earliest days up to the present time. Now our annual requirements exceed forty billion feet of timber, one hundred million cross-ties, four million cords of pulp wood, besides great quantities of other forms of forest products, such as firewood, posts, poles, mine timbers, etc. The per capita consumption of lumber in the United States was 215 board feet in 1850; now it is 470 board feet.

What has been the effect of this tremendous consumption upon our forests? One forest region after another has been attacked. With the exception of Maine, the New England states are cutting mostly second or third growth timber. The box factories there take white pine saplings down to six inches in diameter. The so-called " inexhaustible " white pine forests of Michigan are gone, and millions of acres of cut-over and burned-over land have gone upon the delinquent tax list. Michigan supplied 23 per cent. of the lumber production of the United States in 1880, and less than 5 per cent. of it in 1907. The value of the lumber production in Michigan since 1849 has been 50 per cent. greater than the output of gold in California, and it has all taken place without a thought for the future. The cream of our hardwoods is gone, and it is becoming more and more difficult to get in sufficient quantity the high grades of oak, yellow poplar, ash, and hickory that our great manufacturing industries require. The South's once great supply of yellow pine is rapidly giving way before axe and saw, fire and tornado. Half a generation more will, in most places, see little but remnants left of the Southern forests, and in that time the Pacific coast supplies will be heavily drawn upon.

The prices of forest products have risen more rapidly than those of other commodities. According to the reports of the Bureau of Labor, the quoted prices of the leading kinds of lumber on the New York market have risen twice as much in the last ten years as the average increase in all commodities. This indicates that the supply of timber is not keeping pace with the demand.

Since we cannot get along without timber, it follows that we must take the necessary measures to produce it. The present annual cut of forest products requires at least twenty billion feet of wood. To produce this quantity of wood without impairing the capital stock, our forest land must make an annual increment of 30 cubic feet per acre. Under present conditions of mismanagement and neglect it is safe to say that the average annual increment is less than ten cubic feet per acre for the entire area. This means that *each year's cut* at the present rate takes the growth of more than *three years*. The average age of the trees which are being felled for lumber this year is not less than one hundred and fifty years. The lumberman could not afford to replace them were he blessed with the prospect of unequaled longevity, since such long investments are unprofitable for private capital. In consequence there arises the necessity that the state and national governments, which do not need to look for so high a rate of interest as the private investor, and which are concerned with the promotion of the general welfare, should assume the responsibility of providing a future supply of timber.

The forest area of the United States is sufficient, if rightly managed, to produce eventually timber enough to supply every legitimate need. There is no reason why it should not some day be brought up to the point of yielding an annual increment of more than thirty cubic feet per acre, which will supply the quantity of timber now consumed, and which, if used economically, will be sufficient for a much-increased population.

By way of a concrete example of the necessity for forest preservation, let us note the main facts concerning the proposed Appalachian reserves. The Appalachian region, stretching from New England to northern Georgia, contains 75 million acres of rough or mountain land primarily adapted to the production of hardwood timber, and comprising portions of the watersheds of nearly all of

our great eastern and southern rivers. More than four-fifths of this area has been cut over, and some of it has been cleared, yet it is now furnishing half the annual quantity of hardwood lumber used in the United States. With management according to the principles of modern forestry, the annual growth of timber on this area could eventually be made equal to the quantity of hardwood now annually consumed in the United States.

Some of our greatest and most useful manufacturing industries as conducted at present are absolutely dependent upon a permanent supply of hardwood timber. Among these are cooperage, vehicle and furniture making, the combined annual output of which is valued at upward of four hundred million dollars. The hardwood supply essential for these industries and a multitude of other uses will soon fail unless vigorous action be taken by the national government and the heartiest coöperation be given by the states and individuals most vitally concerned.

Not less essential than for timber production is the proper handling of this great region for watershed protection, the regulation of stream flow to meet the demands of commerce, and the development of power for manufacturing. All the water gathered by the southern Appalachian and White mountains flows to the sea through navigable rivers. In the southern Appalachians there are no natural lakes to gather the flood waters. The only natural factor which tends to equalize the flow of the streams is the forest. In addition to the great property loss which always occurs as the direct result of a flood, there is a still greater though less appreciated loss in soil fertility. In 1896, Professor Shaler said:

"South of Pennsylvania there is, according to my reckoning, based on observations in every state in that upland country, an aggregate area of not less than three thousand square miles where the soil has been destroyed by the complete removal of the woods and the consequent passage of the earthy matter to the lowlands and to the sea. At the rate at which this process is now going on the loss in arable and forestable land may fairly be reckoned at not less than one hundred square miles per annum. In other words, we are each year losing to the uses of man, through unnecessary destruction, a productive capacity which may be estimated as sufficient to sustain a population of a thousand people."

Since that time the cutting of timber, fires and clearing have

greatly accelerated this rate of soil destruction. The property loss resulting from the floods along the Ohio River in January and March, 1907, amounted to nearly ten million dollars, most of which was sustained by the city of Pittsburg. The great loss of life and property which has just occurred in the Carolina floods is too recent to be accurately computed.

The government has already spent or planned to spend some fifty million dollars in an effort to improve the navigability of the streams which have their sources in the southern Appalachians. The total amount of water carried by these streams during the year is amply sufficient for navigation were the flow uniform. The attempt so far has been to *regulate* floods by means of dikes, retaining walls, dams, and locks, and to dredge out resulting bars and flats. This is not enough. It is time to adopt means of *prevention.* The most important of these are the maintenance of forests on the watersheds, and, in addition, the construction of necessary reservoirs to hold the excess run-off and distribute it throughout the year.

The Appalachian streams are of great and increasing importance as sources of power. A fair average of the rental value of the power which it is possible under present conditions to economically develop in the southern Appalachians is nearly forty million dollars a year. The capital invested in the manufacturing enterprises in New England which utilize the power of the streams that rise in the White Mountain region amounts to a quarter of a billion dollars. Water power has a use and value which is in proportion as it is steady and reliable. Such power cannot be obtained from a barren watershed.

The Appalachian region, therefore, is of extreme importance to the East because of its relationship to the hardwood timber supply, navigation, and power. That it must be properly protected cannot longer be questioned. The way to do this is by establishing state and national forests throughout the region, conducted in coöperation with the owners of private timberlands. The interstate relations make the problem primarily one for the general government to undertake. West Virginia cannot be expected to protect the watersheds of the tributaries of the Ohio because Pittsburg and Cincinnati suffer from floods. North

Carolina cannot justly be required to provide its sister states with timber and power. The silt coming from the mountains of eastern Kentucky may be finally deposited in the delta of the Mississippi, and that from western Virginia may choke up the Potomac and the James.

Every argument which is advanced to prove the necessity for protecting watersheds to regulate stream flow applies with redoubled force whenever the run-off from these watersheds is used for city and town supplies.

The national government, then, should acquire the backbone of the great Appalachian ridges, the right management of which is of most importance because of the interstate relations. Other states can establish state forests within their borders, as have New York and Pennsylvania, whose total is nearly two and a half million acres. The West has more than one hundred and sixty million acres of national forests. The East has none. This condition cannot last much longer. The establishment of forest reserves in the Appalachians has been recommended for years by the President, the Secretary of Agriculture, state officials, and a large number of scientific, technical, and trade organizations. The Senate passed the bill providing for these reserves last spring, as it has done before, and the indications are that the House will do so in the near future. When this is done it will mark the most decided advance in the conservation of our natural resources since the establishment of the first National Forest in 1891.

DISCUSSION.

THE PRESIDENT. The subject is now open for discussion,

MR. P. A. MAIGNEN. Is there any tariff on imported wood?

MR. KELLOGG. Yes, sir; there is a tariff of $2 per thousand feet on sawed lumber, but none on logs.

MR. MAIGNEN. In some European countries, where there are divisions of the forests, no more trees can be cut than are planted to take their place, and in some countries even a private owner cannot cut more from one portion of his land than he plants on some other portion. I was wondering if we could not have some such provision enforced in this country.

MR. KELLOGG. It might be possible, but I don't believe it is very probable. The people of the United States do not like restrictions very much, and what we will have to do, I think, aside from the national government acquiring such land as it can, is to use moral suasion rather than force, though there is a considerable sentiment in favor of the regulation of the cutting of timber on private lands. There is no question but what that sentiment is growing in the United States. The most radical step in that direction was taken in Maine last winter. I do not think the bill was passed by the Legislature of Maine, but the Legislature addressed an inquiry to the state Supreme Court, and the Court decided that it would be constitutional to prohibit the cutting of the smaller sizes of timber upon private land, where the cutting of that timber would seriously affect the public interest, having in mind, for one thing, the relation between forests and stream-flow.

MR. R. S. WESTON. I should like to ask Mr. Kellogg what the prevailing view among forestry experts is regarding the best method of reforesting burned-over areas? Is it considered better to let the wood follow along in natural sequence or to replant?

MR. KELLOGG. That depends to some extent upon the locality and the kind of timber. In general, if conditions are at all favorable, foresters are inclined to regard it as better to let Nature bring back the second growth of timber. It takes longer, but is much cheaper. Forest planting is an expensive operation. It will cost anywhere from five dollars an acre up to plant timber on a commercial scale where it has been destroyed either by fire or cutting. It does not cost you anything if conditions are favorable, except waiting a little longer, to let Nature seed over the area; and so, while there are considerable areas in the United States on which we shall have to reproduce our forests by planting, in general we hope to get our future growth of timber more from natural reproduction, simply because it is so much cheaper.

MR. ALLEN HAZEN. How old does white pine have to be before it will seed the adjoining area?

MR. KELLOGG. From about twenty years on. It seeds pretty early and grows rapidly. You will find in New England both natural and planted white pine, between thirty and forty years old, that is being cut and sent to the box factories now.

MR. HAZEN. There are sections of New England through which I drive every summer where the white pine has been exterminated because, generations ago, the farmers thought that it was a weed and that they would be better off if they could clear it all from their farms. On this land only birches and woods of less value now grow. I have sometimes thought that if a white pine could be planted here and there, not very near together, they would grow up and seed the whole country in the course of time, without very much expense.

MR. KELLOGG. They probably would.

MR. HAZEN. No one supports more cordially than I the proposition to establish national forest reserves and to have the government acquire the higher land on the mountain ranges that I am so fond of visiting and climbing over in the summer. I believe most thoroughly in propagating the forests and encouraging and extending them, because we shall need the lumber.

But there is one idea that has gone through this discussion of forest preservation about which I am not satisfied, and that seems to be open to reasonable doubt. I refer to the effect of forests in maintaining the flows of our streams for useful purposes. It has been often assumed that the flow of water from a forested area is larger and more constant and more dependable than from a like area of land that is not forested. I have looked in many places, and through a long period of time, for certain, definite evidence upon this point, but I have found nothing satisfactory. If there is really anything of importance in this idea it would seem that it ought to be possible to secure evidence of it of a nature that could not be questioned.

I am somewhat familiar with the Connecticut valley. I remember the hills that I used to climb years ago, as a boy, from which I could see unbroken forest in all directions. Those areas have now been completely cleared of lumber. They are growing up again, to be sure, as fast as they can, but it is certain that the amount of forest on the catchment area of the Connecticut is much less than it was twenty-five years ago. The flows of the Connecticut River have been recorded by gagings extending over many years. From these records, which I have seen, it appears that the flows (and I refer especially to the summer or dry weather flows) have been

greater in recent years since great inroads have been made in the forest areas than they were twenty-five or thirty years ago, when there was certainly much more forest.

If the inquiry is extended to the Merrimac, the Sudbury, the Croton, and other catchment areas for which accurate gagings are available, so far as I know the same results will be found.

I do not think the flows of recent years have been greater because the forests have been cut off, but there is certainly a great lack of evidence that the cutting off of the forests has reduced the flow.

I was greatly interested in Australia last year in finding that some of the engineers and water-works people had exactly the reverse idea from the one which seems to be current here. The catchment areas which serve to supply some Australian cities are covered with forest of a density which can hardly be imagined by one who is only familiar with forests in cool climates; and the idea is held very firmly and by many people that these forests take the water which falls upon them and upon the ground and evaporate it and dissipate it and prevent it from flowing off to the reservoirs that supply the cities; and thousands of acres of those forests upon catchment areas have been ring barked to kill the trees, with the idea of preventing the dissipation of the water by them, and in this way of securing a larger amount to supply the cities.

I inquired for data that would justify this practice, and it is only fair to say that I was as little satisfied as to its being well founded as I am in doubt as to whether the opposite view is well founded in our climate.

I should like to ask Mr. Kellogg how far he has studied this matter, and if he has any figures of any description that are reliable and certain which indicate, or which even tend to indicate, that the run-off from forested areas is greater or more certain than from like areas that are not forested.

MR. KELLOGG. There are a great many things that complicate the matter, as Mr. Hazen has evidently found out on going into it a little. The only way to ever answer the question on a scientific basis is to have a long series of various kinds of records, — records of the actual condition of the watershed so far as its cover is concerned: whether it is timbered or cut over or burned over or grassed; an accurate knowledge of what the geological formation

is; what the shape of the drainage basin is; an accurate record of the precipitation through a series of years, and an accurate record of the run-off or gagings of the streams. It seems to me we must have all this evidence in order to answer the question, because all these factors influence the run-off, and we do not have such complete knowledge, so far as I know, upon any drainage basin in the United States. If I am wrong, I hope Mr. Hazen or Mr. Parker will correct me. Because we do not know these things at present, we have to draw our conclusions from what meager data we do have, and also somewhat from theoretical considerations. It does look from some data as though there were a close connection, while other data do not seem to show anything either way, — I will say that frankly. The figures I read here a little while ago indicate pretty strongly that there has been an increase in the run-off of certain of our important rivers, and we know that during the period covered by the record the only change which has taken place on the watershed has been the cutting off of a considerable quantity of timber. The records which I read here, which extend in some cases over a period as long as seventy years, show an increase in the number and duration of floods in such rivers as the Ohio and the Cumberland.

The theoretical considerations are something like this. We know that where we have a forest for a long time upon an area which is not damaged by fire, we get a gradual accumulation from decaying trees, leaves, and undergrowth which makes a blanket over the surface of the ground, and that blanket is somewhat in the nature of a sponge. It would certainly seem that when water falls upon such a blanket it would be retarded in its flow and more would sink into the ground than if we had a barren watershed covered only with rock, or possibly with gravel or very hard soil,

I do not think it is at all common to claim that the total run-off from a watershed is likely to be increased by having a forest upon it. The total run-off in a series of years may be just as great from a forested watershed as from a barren watershed, but it would seem that the run-off would be regulated, that the floods might be strung out further and not reach as high a stage, and that the low-water stage might not be so low in the case of a protected watershed as in the case of a non-protected watershed.

This matter which Mr. Hazen brought up in connection with Australian watersheds, that is, the loss of water by its being taken up and transpired into the atmosphere by the forest, probably has quite a little in it; but, on the other hand, such observations as have been made, particularly in Germany, indicate that there is no more moisture transpired by forests than there is by a covering of grass or some other kind of vegetation. But it certainly does seem reasonable that a forest must have a good deal of restraining influence upon the run-off, and it is unquestionable that the run-off from a well-protected watershed does not carry nearly as much silt as it carries from an unprotected watershed. We have case after case of the most striking kind, particularly through the South, where, when the timber has been removed, erosion of the face of the country has immediately set in, and set in where it did not exist before; and that means that your water is polluted to a certain extent, and it most certainly means that your water course is filling up with silt.

MR. FRANK L. FULLER. Mr. President, this matter which Mr. Hazen has spoken of I think is very important, and I have often thought of it myself, because we all know how the roots of trees will run down into the soil in search of moisture. We have seen the roots of elm-trees running into sewer pipes and into all sorts of moist places, apparently seeking to get to water. I noticed some time ago, in a covered reservoir, where some cracks had been made by a settlement in the bank, causing a slight aperture through the concrete, which was covered with earth, grass roots had gone down three or four feet, I should think, to get at the moisture underneath. It was rather surprising to me that those roots should have extended down so far.

It seems to me that some experiments should be made, and I wonder that they have not been made, as to how much moisture a tree will take up. It would seem as though a tree might be planted in some sort of an inclosed watertight basin, supplied with water, and in some way the amount of moisture taken up by the tree and evaporated gotten at. Of course any amount of water which is evaporated into the air is so much lost to the soil, and, therefore, lost to the drainage area. It may fall again on the same drainage area in the form of rain, but it may not.

There is one other thought which occurs to me, and that is in connection with the retention of snow in the forests. Mr. Kellogg did not mention that matter, but he can probably give us some information in regard to it. Oftentimes we go into the woods in New England as late, perhaps, as the latter part of May, and find considerable snow retained in the shady portions of the forest. That snow, of course, will gradually get into the streams, and will cause much less variation in the flow of the stream than it would have caused if it had all gone off suddenly, as it would have done if the area had been unwooded. It seems to me there is one point where the advantage of a wooded area is considerable.

MR. KELLOGG. That is what ordinarily occurs, but let me give an instance on the other side which will bear out the point Mr. Hazen made that there is a great diversity of opinion on these subjects. A man told me not long ago that in his opinion the forests in the southern Appalachian hills are really responsible for the floods. His idea was that the snow collected in the forest during the winter and then melted and went out all at once in the spring, and that made the floods.

MR. FULLER. I suppose that in case of a warm rain the snow would go out fast, and perhaps some of our heaviest floods are caused in that way, — by the combined effect of the melting snow and the rain, — but it would seem as though the snow being retained and held back by the forest was an advantage.

MR. KELLOGG. In general it would seem as though that were so, but I cannot say offhand what the European observations have been, so far as the effect of the retention of snow upon the subsequent run-off is concerned. The European observations, as I recollect, show, as I said a minute ago, that the amount of water transpired by forest is at least no greater, and in some cases less, than by other forms of vegetation. You get transpiration everywhere where there is vegetation, because water performs its function in plant life principally as it is transpired. It acts there somewhat as in the development of water power. It is only as water passes from one condition to another that its use is developed.

MR. HAZEN. Mr. Kellogg has described the humus blanket, so-called, and its supposed effect in maintaining flow. I think that

his principle is right, but it is my idea, after giving the matter considerable attention, that the real blanket which holds the winter water and gives it up in summer is the layer of glacial drift that is found on nearly all of our northern streams, and also the older deposits with similar physical properties which occur along the Atlantic coast to the southward, and other similar pervious deposits in other parts of the country. I know that this material is often many feet in depth and is pervious and has a great capacity for taking up water and holding it and giving it out slowly, and we know, from the records of rainfall and of run-off, that this material, or some material, holds back the rainfall in the months of excess and gives it out in the months of deficiency, and it seems to me that this pervious, gravelly material has so much greater capacity in this respect than any possible humus layer could have that the influence of the humus, if any, must be trifling in amount in comparison with that of the sand and gravel blanket.

MR. W. C. HAWLEY. It may be of interest to call attention to the fact that the flood in the Allegheny River last year was the most serious flood they ever had, and as the result of the drought which western Pennsylvania has been experiencing for some two or three months, the streams in that locality are to-day lower than they have been for a period of perhaps forty or fifty years. I haven't any exact data on that, but statements have been published in the newspapers within the last week or ten days to that effect. Of course the forests on the Allegheny River have been to a considerable extent removed. The banks have been encroaching more or less upon the stream in the vicinity of Pittsburg, also, from year to year, as they have been built upon, and this may account in part for the flood last year reaching so unusual a height.

MR. ALBERT BLAUVELT. I should like to ask the reader of the paper whether any of the data concerning water flow have been made out on the idea that the question is one of relation of the forest to the character of the earth's surface. I don't know that I make myself clear. We know perfectly well that a tree itself takes up a great deal of water and evaporates it into the atmosphere. That water never reaches the ground at all. It also holds a great deal of snow in the winter time, which melts on the tree in warm days and returns to the atmosphere, wholly irrespective of the

breathing action of the tree or moisture drawn from the ground. We know very well if we had a surface made of sheet tin, with convenient flow points, like the roof of a house, and had sponges on it instead of forest, we would retain considerable water, but otherwise we would immediately have a rapid run-off. Now I am asking for information whether the studies have gone into a consideration of the thought that the real point may be, not whether forest is present or absent, not whether the soil is water-tight on the surface or is capable of retaining great quantities of moisture, as the last speaker mentioned, but whether it is not a question of what are the relations between those two. In other words, if you have a surface soil capable of quick drainage and incapable of retaining water, then you must have forests. And cannot some of these discrepancies be explained on the ground that where there is a lack of water you have a surface which has failed to retain the water? In other words, that you can have a well-regulated flow either with plenty of forest or a good absorbent surface to the earth, but you must have one or the other, and you will get into trouble if you fail as to both.

MR. KELLOGG. I think that is a point well stated. The records which have been taken up to the present time I do not believe have been from that standpoint, and that is particularly true of the earlier records, because we began this work in rather a haphazard fashion, without taking all the factors into consideration. When the first records on some of these streams were taken seventy years ago nobody thought of forestry. That didn't get started in the United States until sixteen or seventeen years ago, and it has only been since that time we have been considering some of these questions. We are just now getting at the heart of them. Heretofore we have had only partial records, in some cases of the rainfall and in some cases of the condition of the watershed, and when we try to tie them up we find that they were not taken with the object in view of correlating these different things, because we hadn't got that far into the subject.

MR. BLAUVELT. Personally, I believe that we must have a sponge either in the forest or on the ground.

MR. KELLOGG. I should think so, and that suggests a question I wanted to ask in regard to the New England streams. Does any-

body here remember how far south the line of glacial drift extends? My remembrance is that it is not south of New York.

A MEMBER. It goes to New Brunswick, N. J.

MR. HAZEN. And there are tertiary deposits beyond that, which have the same characteristics, extending down through New Jersey.

MR. M. N. BAKER. It is quite evident from the discussion we have had this afternoon that there is much need of giving careful attention to the subjects which have been before us. The question of the transpiration of forest growths is discussed in Fernow's "Economics of Forestry." (1902.) Some years ago, Mr. C. C. Vermeule and the late George W. Rafter, and others, discussed forests and run-off before the American Forestry Association. The latest contribution to the subject has just been made public in an advance copy of a paper by Lieut.-Col. H. M. Chittenden. (Proceedings of the American Society of Civil Engineers, for September, 1908.)

I think the consensus of opinion here agrees quite well with the consensus of opinion generally, as far as one can gather it, and that is that forests have comparatively slight influence upon rainfall, but more influence, however, upon the run-off, and that their influence upon the run-off is more in equalizing the flow, particularly floods. The forest floor, or blanket, or sponge, as it has been called, has a very great influence upon violent fluctuations of stream flow.

The effect of forests upon the distribution of the run-off as related to the snowfall is also very material. Some years ago Prof. L. G. Carpenter, of Fort Collins, Colo., brought out a very interesting bulletin dealing with this matter of snowfall retention in forested area. On June 24 of this year, in company with the American Society of Civil Engineers, I was up at about an elevation of 11 660 feet, on one of the railways which is being built from Denver through to Salt Lake City. As we got up toward that altitude we saw very unmistakable evidences of the effect of forest upon the snow. In the heavily wooded areas along the railroad track there were snow banks many feet in thickness, whereas out where the sun would strike, and where there was a southern exposure, there was practically no snow at all.

MR. H. N. PARKER. Mr. President, it seems to me that this discussion gives point to a portion of Mr. Leighton's paper, in which he said it was necessary for us to take up these problems as a whole. In the past a lack of proper legislation and possible lack of breadth of view on the part of investigators has led us to consider each question by itself, so while we have had gaging stations, for instance, established on the rivers, it may be that they have not been established at places where at the same time observations could be made of the effect of cutting off the forest and the work which the forestry bureau was doing. It seems to me we have got to proceed in a businesslike as well as scientific sort of way in the investigation of all these matters connected with the conservation of our natural resources, and, as Mr. Leighton said, educate the ordinary citizen up to the point where he will insist on his state legislature, his municipal government, and the national government appropriating funds to carry on this work through a sufficient length of time to get definite results.

PROF. EDWARD W. BEMIS. Mr. President, I think this discussion has been very valuable. It may be worth while to bear in mind that whatever doubt we may have as to the effect of forests upon the fall of water, there is no doubt, as Mr Hazen has expressed it, as to the importance of the forest policy of the government in relation to the timber supply, and there seems to be some degree of warrant for the opinion that it has a probable effect upon climate and upon the rainfall; so that while we are still having some doubts as to the full effect of the forests upon the water supply, we are sure enough of our other points to uphold the policy of the government for a large development of government forests and a thorough investigation by the government of the forestry question.

I believe Europe must have exact data, such as have been called for to-day and not produced, upon the flow of water in rivers. I can hardly imagine that the French and German governments could have carried on their works as many years as they have without getting very definite data, which no one here seems to be able to quote, on that one point of the flow of water. But, as I say, that is one point only, and we may still have our doubts on that and have no doubt whatever on the general policy of the government on the subject.

It has seemed to me for a long time that the decades to come will look upon the present administration as having performed its absolutely greatest service, of all the many services it has performed, in its conservation of our natural resources. That, it seems to me, we can have very little doubt upon. It has been the great stock argument, as you are doubtless aware, of many of the economists, that the forestry question is the absolute proof of the mistake of the individuals, and of the philosophy of Herbert Spencer and others, in their theory that the interests of the individual and the interests of society are identical. The forestry question has been often cited as the absolute proof of the falsity of that opinion, because the individual's interests do not run generally over twenty or thirty years, while it takes from forty to one hundred years to develop the economic value of the forests, and, therefore, only society in its organized capacity is able to look upon the question broadly. The individual cannot look on it broadly because the individual wants to reap in his own lifetime. And in so far as it is not purely a question of lumber or timber which may be grown in the lifetime of the individual owner, and so far as there is any effect on climate, or on the rainfall, and broadly on the country, that, of course, is altogether a benefit to society at large, and, therefore, only society at large can take an interest in the subject.

I think there is enough evidence already at hand to warrant the idea that, independent of any party affiliations, we cannot too strongly approve large acquisitions of government forests. One of the beauties of this moment is that it is independent of all partisan spirit. The movement is becoming a general one, but does not seem yet to overcome the opposition of certain selfish interests in the House of Representatives. I think, however, in the country at large, the sentiment is getting to be almost overwhelming, and it is for us to make it more so if possible. I have enjoyed this discussion very much indeed, and I hope that we may be able, or Mr. Kellogg may be able, to turn to the French and German data, for I am sure that there must be such, on the point which has been especially discussed to-day.

A MEMBER. When I was a small boy there used to be a great deal said about the cutting off of the forests, that it was going to

decrease the rainfall; I don't hear anything said about that subject nowadays. I have had occasion to work somewhat on a small scale and argue from the smaller to the greater. It would seem as if it were reasonable, perhaps, that if we cut off the forest we thereby open up more and more freely the channel ways for the water, and that, therefore, the water would get quicker to its main outlet and would seem to be increased in quantity, there would be greater floods, and we would get the impression that there was a greater total amount; while with the trees in large areas there is less free access to the water channels and, therefore, a greater regulation of the flow.

I should like to know whether there has been in the forestry examinations anything on the first point, that is, a decreased actual total rainfall. I have noticed this on small tracts. We have had occasion to look up many cases of claims for damages due to development of localities. People have come in and been almost black in the face over the damage done by floods. They have said, " All my ancestors, and the people from whom I bought the property, never knew such floods; we have more water coming down to-day than ever came before." That is what I have heard day after day. Now, what is the fact? The fact is, that the rainfall statistics show the same averages, fluctuating up and down, up and down, up and down, but practically the same that they were fifty years ago; but the development of the region, the building of streets, the draining of swamps, the removal of small tracts of forest, allows the water to flow more quickly. I imagine that that is going to be one of the serious points in connection with our forestry conservation. If we can control the water by dams and reservoirs of various sizes, by improved lands and some forest, we will get the same result from the point of view of the conservation of the water that we would from actual forest lands.

Mr. Parker. We all know the effect of a wagon track through a forest region, and have seen on the mountain side how the water will seek such a track and flow down rapidly through that free channel way. There are very many things which complicate this problem which we are now discussing.

Mr. George A. King. I should like to ask Mr. Kellogg if he has any figures as to the waste of lumber and wood in forest fires, and

if that is not one of the most serious problems in the protection of the forests.

MR. KELLOGG. It is unquestionably one of the most serious problems we have, and it is more serious from the standpoint of private forestry than any other thing. We haven't any reliable data upon the annual loss from forest fires in the United States. It has been estimated at from $25 000 000 to $100 000 000. We intend within the next month or two to begin the collection of statistics on the damage by forest fires in the United States in 1908. The fires this year throughout the United States have been worse than they have any year since the noted fires in Minnesota in 1894, and we are going to get all the information possible in regard to them.

There is absolutely no question that fire is one of the most serious hindrances to the practice of forestry by individuals and by large companies and corporations in the United States, but there is also absolutely no question that fire can, in the main, be prevented. It is being done almost completely in the national forests. We haven't entirely eliminated fires, but we have almost, so that the amount of timber which is destroyed by fire each year in the national forests is almost negligible as compared with the amount of timber in those forests. On the other hand, it was true, up to the time of the establishment of the national forests in the Rocky Mountain region, that enormous quantities of timber were destroyed by fire. Fires are preventable, but with the exception of what has been done by the national government and by two or three states, they have not been prevented.

MR. MORRIS KNOWLES. I had occasion some time ago to look up some foreign records. In a translation by one of the army officers (Gen. Godfrey Weitzel, of the United States Engineer Corps) of a paper by Gustav Wex, reference is made to observations upon some of the streams of Germany and Austria, running back some one hundred to one hundred and fifty years. While the data were not entirely complete, conclusions were drawn as to the relation of forests to run-off. It appears that floods had increased for those areas where the forests had been cut away, but no mention was made in regard to rainfall or its distribution, or of many other conditions; simply the fact was given that the forests had

been cut off and that certain stream flows showed that for recent periods there were notably higher floods and lower summer flows than before.

I believe the distribution of the rainfall is one of the most important items, and upon this we have had but little data until recent years.

The late flood in the Ohio Valley, which was one of the largest ever recorded, was from a rainfall upon a limited area, mostly upon one tributary, namely, the Monongahela. It backed up into the Allegheny somewhat, and produced in the Ohio River a marked flood. The distribution of the rainfall as to the season and as to the different portions of the watershed, and as to the state of the soil and vegetation, must have a great effect upon the surface run-off.

Until facts can be secured along this line, where there are so many different opinions, no definite conclusions can be reached. We need more information, our discussions are based upon insufficient data, and I hope that this consideration of the subject will cause us all to use our influence with those who vote and appropriate the public moneys for the uses of such departments of our government, to see that there shall be liberal allowances to conduct such investigations. We may not realize the benefit in our day; as Professor Bemis has well said, it is a work for society as a whole, because of its long-continued effect; but by securing the data we shall have done something for the benefit of those who come after us.

Mr. A. A. Reimer. Our city of East Orange, N. J., has gone into this matter within the last year and started on our watershed the development of a nursery and plantation. We have about eight hundred acres, and of this, possibly 30 per cent. is a sort of rough forest. We have not gone at this question with the view of conserving the water supply primarily, for it will probably have no direct effect upon that at present, as our supply is entirely from artesian wells, but we have gone at it from the standpoint of lumber values, not figuring for to-day, of course, but for the future. We are making a very thorough study of the question. The state has lent us its expert, Mr. Alfred Gaskill, who is our general adviser, and we are following out his plans to the letter, and hope that in the course of ten years we will have as hand-

some a stand of fine lumber as can be found in our region. We have it in mind that this will be an object lesson, and we hope eventually that others around us will see the good result, and thereby we may receive a benefit to our water supply, as we realize that if there is anything in the idea of the retention of the rainfall by forests, artesian supplies will receive the same benefit that surface supplies will, and if forest areas can be developed within from three to ten miles of us on land which to-day is absolutely worthless for anything but forest, we believe we will receive in that way a benefit to our water supply. So we are not entirely unselfish, either from the standpoint of water supply or lumber, but at present the main point is the lumber supply, and we are developing a tract of land that in the next thirty to fifty years will furnish the finest kind of lumber.

MR. M. N. BAKER. It ought to be noted, I think, in connection with this discussion, that for some years past a number of municipalities and a few private water companies have been going quite extensively into the same line of work that has been mentioned by the last speaker. Four or five years ago I gathered quite a lot of information regarding forestry works on water-works drainage areas. I should suppose that since that day there must have been many municipalities, and perhaps a few more companies, who have joined ranks of those who at that time had taken up the work. As I remember it, there were half a dozen or some such number of rather notable instances of forestal work on drainage areas of American water supplies. In England considerable work of this kind has been done, and some very interesting reports have been made on forestry operations by the Liverpool works.

STREAM FLOW DATA.

BY CHARLES E. CHANDLER, CIVIL ENGINEER, NORWICH, CONN.

[*Read September 24, 1908.*]

At the November, 1907, meeting in Boston, I presented some tables of stream flows which were, with the accompanying explanations, printed in the December, 1907, JOURNAL.

Later I had tables prepared showing the flow of other streams,

TABLE No. 10.*

SUDBURY RIVER AT FRAMINGHAM. DRAINAGE AREA, 75 SQUARE MILES.

Monthly flows in second-feet per square mile, arranged chronologically.

Year.	Jan.	Feb.	Mch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1875	0.159	2.315	2.482	4.718	1.838	1.346	0.497	0.612	0.321	1.000	2.015	0.903
1876	0.995	2.116	6.862	5.094	1.761	0.343	0.283	0.627	0.285	0.361	1.683	0.702
1877	1.019	1.469	7.448	3.703	2.153	0.924	0.312	0.187	0.092	0.977	2.193	1.995
1878	2.800	3.814	5.426	2.516	2.158	0.782	0.199	0.736	0.249	0.799	2.619	4.916
1879	1 083	2.647	3.605	4.821	1.723	0.640	0.243	0.611	0.218	0.109	0.318	0.716
1880	1.733	2.765	2.126	1.808	0.796	0.271	0.273	0.184	0.124	0.157	0.318	0.271
1881	0.642	2.392	6.195	2.392	1.493	2.070	0.428	0.229	0.305	0.287	0.611	1.199
1882	1.920	3.718	4.392	1.342	1.998	0.818	0.133	0.086	0.474	0.463	0.324	0.487
1883	0.518	1.598	2.492	2.088	1.450	0.464	0.178	0.122	0.141	0.288	0.317	0.299
1884	1.540	4.397	5.857	4.415	1.594	0.644	0.346	0.397	0.068	0.129	0.271	1.431
1885	1.910	2.095	2.433	2.808	2.067	0.659	0.096	0.372	0.187	0.519	1.822	1.816
1886	2.260	7.428	3.185	3.013	1.114	0.314	0.179	0.146	0.182	0.225	1.041	1.578
1887	4.006	4.377	4.437	4.053	1.561	0.640	0.178	0.331	0.172	0.294	0.570	0.995
1888	1.629	3.011	5.009	4.093	2.526	0.652	0.182	0.587	1.786	3.093	4.267	4.708
1889	4.305	1.850	2.071	2.182	1.361	1.011	0.980	2.216	1.274	1.903	3 003	3.467
1890	1.941	2.366	5.636	2.900	2.114	0.878	0.166	0.204	0.708	3.515	1.879	1.541
1891	4.669	5.393	6.889	3.708	0.902	0.639	0.231	0.252	0.314	0.325	0.472	0.842
1892	2.893	1.459	3.024	1.347	1.948	0.662	0.331	0.433	0.354	0.195	1.088	0.750
1893	0.671	2.386	5.020	3.287	4.460	0.681	0.244	0.280	0.167	0.343	0.494	1.242
1894	1.082	1.533	3.462	2.537	1.299	0.648	0.249	0.323	0.232	0.579	1.293	1.108
1895	1.600	0.837	3.728	3.901	0.984	0.270	0.357	0.354	0.138	2.133	4.296	2 767
1896	1.677	4.140	5.937	2.311	0.557	0.617	0.147	0.088	0.600	0.916	1.019	1.016
1897	1.307	1.651	3.968	2.290	1.416	1.488	1.018	0.914	0.282	0.145	1.406	2.450
1898	2.534	4.675	4.028	2.829	1.928	0.820	0.357	1.713	0.571	1.795	3.072	2 783
Av.	1.871	2.935	4.405	3.090	1.717	0.762	0.317	0.500	0.385	0.856	1.516	1.616

* Note that numbers of tables are consecutive with those in the previous paper (JOURNAL, December, 1907, p. 464).

and both sets with explanations were printed in the 1908 Proceedings of the Connecticut Engineers' Association. I suggested to Mr. Kent that these additional tables might be printed in some number of the JOURNAL if it were thought best, and he desired that I present them here.

Three of the additional tables presented contain Sudbury data. The tables presented to the Connecticut Association included the thirty-two years, 1875 to 1906. The months showing minus flows were something of a stumbling block. Mr. FitzGerald has written me that the passing of so much Nashua River water through the Sudbury watershed during the years since 1898 makes the deduced

TABLE No. 11.

SUDBURY RIVER AT FRAMINGHAM. DRAINAGE AREA, 75 SQUARE MILES.

Monthly flows in second-feet per square mile arranged in order of magnitude for each year.

Year.	1	2	3	4	5	6	7	8	9	10	11	12
1875	0.159	0.321	0.497	0.612	0.903	1.000	1.346	1.838	2.015	2.315	2.482	4.718
1876	0.283	0.285	0.343	0.361	0.627	0.702	0.995	1.683	1.761	2.116	5.094	6.862
1877	0.092	0.187	0.312	0.924	0.977	1.019	1.469	1.995	2.153	2.193	3.703	7.448
1878	0.199	0.249	0.736	0.782	0.799	2.158	2.516	2.619	2.800	3.814	4.916	5.426
1879	0.109	0.218	0.243	0.318	0.611	0.640	0.716	1.083	1.723	2.647	3.605	4.821
1880	0.124	0.157	0.184	0.271	0.271	0.273	0.318	0.796	1.733	1.808	2.126	2.765
1881	0.229	0.287	0.305	0.428	0.611	0.642	1.199	1.493	2.070	2.392	2.392	6.195
1882	0.086	0.133	0.324	0.463	0.474	0.487	0.818	1.342	1.920	1.998	3.718	4.392
1883	0.122	0.141	0.178	0.288	0.299	0.317	0.464	0.518	1.450	1.598	2.088	2.492
1884	0.068	0.129	0.271	0.346	0.397	0.644	1.431	1.540	1.594	4.397	4.415	5.857
1885	0.096	0.187	0.372	0.519	0.659	1.816	1.822	1.910	2.067	2.095	2.433	2.808
1886	0.146	0.179	0.182	0.225	0.314	1.041	1.114	1.578	2.260	3.013	3.185	7.428
1887	0.172	0.178	0.294	0.331	0.570	0.640	0.995	1.561	4.006	4.053	4.377	4.437
1888	0.182	0.587	0.652	1.629	1.786	2.526	3.011	3.093	4.093	4.267	4.708	5.009
1889	0.980	1.011	1.274	1.361	1.850	1.903	2.071	2.182	2.216	3 003	3.467	4.305
1890	0.166	0.204	0.708	0.878	1.541	1.879	1.941	2.114	2.366	2.900	3.515	5.636
1891	0.231	0.252	0.314	0.325	0.472	0.639	0.842	0.902	3.708	4.669	5.393	6.889
1892	0.195	0.331	0.354	0.433	0.662	0.750	1.088	1.347	1.459	1.948	2.893	3.024
1893	0.167	0.244	0.280	0.343	0.494	0.671	0.681	1.242	2.386	3.287	4.460	5.020
1894	0.232	0.249	0.323	0.579	0.648	1.082	1.108	1.293	1.299	1.533	2.537	3 462
1895	0.138	0.270	0.354	0.357	0.837	0.984	1.600	2.133	2.767	3.728	3.901	4.296
1896	0.088	0.147	0.557	0.600	0.617	0.916	1.016	1.019	1.677	2.311	4.140	5.937
1897	0.145	0.282	0.914	1.018	1.307	1.406	1.416	1.488	1.651	2.290	2.450	3.968
1898	0.357	0.571	0.820	1.713	1.795	1.928	2.534	2.783	2.829	3.072	4.028	4.675
Av.	0.198	0.283	0.450	0.629	0.813	1.086	1.355	1.648	2.250	2.810	3.584	4.911

flow less precise than in previous years. The years since 1898 contain all the minus months. On this account the Sudbury tables presented to-day include only the twenty-four years, 1875 to 1898, and probably the flow of these years is more useful than the flow of the thirty-two years. This makes the tables of permanent value without further modification.

The present tables include the Nashua flows for ten years, 1897 to 1906, arranged chronologically, in order of magnitude yearly, and in order of magnitude for full term. This table will be modified by the addition of future data.

The Merrimac data for seventeen years, 1890 to 1906, measured weekly, are given in order of magnitude. This table will be modified by both future and previous records when they are available.

This table is accompanied by one giving the number of weeks in the average of these years that any given flow has occurred and at any development the percentage available. It seems to me that these Merrimac tables, prepared from data furnished by Mr. Hale, are well worth the labor they cost.

I hope that next year Mr. Hale will give us the Merrimac data chronologically and in order of magnitude for each year, and for the full term from a much earlier date than 1890 up to 1908, and that other engineers having such data regarding other streams will give us all the benefit of them, at least chronologically.

Now I wish the limitations of this and preceding papers to be distinctly understood. There is no attempt to make a rule for determining the available flow of every or any particular stream under all circumstances. The aims and objects are:

1. To put in print for the use of all members, data heretofore not in print, or available to but few members.

2. To put these data in form of second-feet per square mile instead of second-feet for the particular place where the measurements were made.

3. To arrange these data not only chronologically, which in many cases is the most useful form, but also in order of magnitude for each year.

4. To also arrange the data in order of magnitude for full term, which is an unusual, but more precise, method of eliminating all unavailable storm flows in water-power developments.

5. The available percentage of the flow for any development is added in some cases.

These are basic tables. They can be used without modification for twenty-four hour per day use. For ten or eleven hours the results at different seasons of the year must be modified according to the opportunities on the stream for night storage and other local conditions.

The papers by Messrs. Main, Herschel, and Hale, printed in the September, 1907, JOURNAL, leave little to be desired in the way of methods for the application of stream flow data to especial cases.

TABLE No. 12.

SUDBURY RIVER AT FRAMINGHAM. DRAINAGE AREA, 75 SQUARE MILES.

Monthly flows in second-feet per square mile arranged in order of magnitude of whole term, 1875 to 1898 inclusive.

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.068	0.182	0.283	0.357	0.612	0.837	1.114	1.594	1.948	2.392	3.072	4.392
2	0.086	0.184	0.285	0.357	0.617	0.842	1.199	1.598	1.995	2.392	3.093	4.397
3	0.088	0.187	0.287	0.361	0.627	0.878	1.242	1.600	1.998	2.433	3.185	4.415
4	0.092	0.187	0.288	0.372	0.639	0.902	1.274	1.629	2.015	2.450	3.287	4.437
5	0.096	0.195	0.294	0.397	0.640	0.903	1.293	1.651	2.067	2.482	3.462	4.460
6	0.109	0.199	0.299	0.428	0.640	0.914	1.299	1.677	2.070	2.492	3.467	4.669
7	0.122	0.204	0.305	0.433	0.642	0.916	1.307	1.683	2.071	2.516	3.515	4.675
8	0.124	0.218	0.312	0.463	0.644	0.924	1.342	1.713	2.088	2.526	3.605	4.708
9	0.129	0.225	0.314	0.464	0.648	0.977	1.346	1.723	2.095	2.534	3.703	4.718
10	0.133	0.229	0.314	0.472	0.652	0.980	1.347	1.733	2.114	2.537	3.708	4.821
11	0.138	0.231	0.317	0.474	0.659	0.984	1.361	1.761	2.116	2.619	3.718	4.916
12	0.141	0.232	0.318	0.487	0.662	0.995	1.406	1.786	2.126	2.647	3.728	5.009
13	0.145	0.243	0.318	0.494	0.671	0.995	1.416	1.795	2.133	2.765	3.814	5.020
14	0.146	0.244	0.321	0.497	0.681	1.000	1.431	1.808	2.153	2.767	3.901	5.094
15	0.147	0.249	0.323	0.518	0.702	1.011	1.450	1.816	2.158	2.783	3.968	5.393
16	0.157	0.249	0.324	0.519	0.708	1.016	1.459	1.822	2.182	2.800	4.006	5.426
17	0.159	0.252	0.325	0.557	0.716	1.018	1.469	1.838	2.193	2.808	4.028	5.636
18	0.166	0.270	0.331	0.570	0.736	1.019	1.488	1.850	2.216	2.829	4.053	5.857
19	0.167	0.271	0.331	0.571	0.750	1.019	1.493	1.879	2.260	2.893	4.093	5.937
20	0.172	0.271	0.343	0.579	0.782	1.041	1.533	1.903	2.290	2.900	4.140	6.195
21	0.178	0.271	0.343	0.587	0.796	1.082	1.540	1.910	2.311	3.003	4.267	6.862
22	0.178	0.273	0.346	0.600	0.799	1.083	1.541	1.920	2.315	3.011	4.296	6.889
23	0.179	0.280	0.354	0.611	0.818	1.088	1.561	1.928	2.366	3.013	4.305	7.428
24	0.182	0.282	0.354	0.611	0.820	1.108	1.578	1.941	2.386	3.024	4.377	7.448
Av.	0.138	0.235	0.318	0.491	0.694	0.981	1.395	1.773	2.149	2.692	3.783	5.367

TABLE No. 13.

SOUTH BRANCH NASHUA RIVER AT CLINTON. 119 SQUARE MILES.

Monthly flows in second-feet per square mile, arranged chronologically.

	Jan.	Feb.	Mch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1897	1.232	1.440	4.270	2.525	1.800	1.828	2.231	1.386	0.528	0.377	1.984	3.521
1898	2.418	2.530	4.778	3.137	2.151	1.281	0.514	2.049	1.045	2.334	3.358	3.189
1899	3.236	1.687	4.295	5.224	1.344	0.869	0.548	0.365	0.387	0.379	0.665	0.555
1900	1.232	6.271	5.759	2.444	2.139	0.894	0.336	0.304	0.197	0.437	1.354	2.429
1901	0.803	0.551	4.205	7.711	4.222	1.525	0.738	0.792	0.495	1.001	0.799	5.002
1902	2.579	2.168	6.176	3.341	1.595	0.635	0.452	0.459	0.372	1.471	0.982	2.859
1903	1.957	3.300	5.297	3.463	0.880	3.297	0.966	0.734	0.580	1.065	0.981	1.476
1904	1.020	1.434	4.653	4.617	2.317	1.179	0.769	0.549	0.764	0.538	0.530	0.680
1905	1.959	0.700	4.648	2.502	0.688	0.838	0.565	0.497	1.900	0.567	0.684	1.575
1906	1.757	1.588	2.878	3.263	2.371	1.831	1.127	0.915	0.428	0.820	1.160	1.229
	1.819	2.167	4.696	3.823	1.951	1.418	0.825	0.805	0.670	0.899	1.250	2.252

TABLE No. 14.

SOUTH BRANCH NASHUA RIVER AT CLINTON. 119 SQUARE MILES.

Monthly flows in second-feet per square mile arranged in order of magnitude by years.

	1	2	3	4	5	6	7	8	9	10	11	12
1897	0.377	0.528	1.232	1.386	1.440	1.800	1.828	1.984	2.231	2.525	3.521	4.270
1898	0.514	1.045	1.281	2.049	2.151	2.334	2.418	2.530	3.137	3.189	3.358	4.778
1899	0.365	0.379	0.387	0.548	0.555	0.665	0.869	1.344	1.687	3.236	4.295	5.224
1900	0.197	0.304	0.336	0.437	0.894	1.232	1.354	2.139	2.429	2.444	5.759	6.271
1901	0.495	0.551	0.738	0.792	0.799	0.803	1.001	1.525	4.205	4.222	5.002	7.711
1902	0.372	0.452	0.459	0.635	0.982	1.471	1.595	2.168	2.579	2.859	3.341	6.176
1903	0.580	0.734	0.880	0.966	0.981	1.065	1.476	1.957	3.297	3.300	3.463	5.297
1904	0.530	0.538	0.549	0.680	0.764	0.769	1.020	1.179	1.434	2.317	4.617	4.653
1905	0.497	0.565	0.567	0.684	0.688	0.700	0.838	1.575	1.900	1.959	2.502	4.648
1906	0.428	0.820	0.915	1.127	1.160	1.229	1.588	1.751	1.831	2.371	2.878	3.263
	0.436	0.592	0.734	0.930	1.041	1.207	1.399	1.815	2.473	2.842	3.874	5.229

TABLE No. 15.

South Branch Nashua River at Clinton.

Monthly flows in second-feet per square mile arranged in order of magnitude of whole term, regardless of the years.

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.197	0.452	0.551	0.700	0.869	1.065	1.386	1 751	2.151	2.525	3.300	4.648
2	0.304	0.459	0.555	0.734	0.880	1.127	1.434	1.800	2.168	2.530	3.341	4.653
3	0.336	0.495	0.565	0.738	0.894	1.160	1.440	1.828	2.231	2.579	3.358	4.778
4	0.365	0.497	0.567	0.764	0.915	1.179	1.471	1.831	2.317	2.859	3.463	5.002
5	0.372	0.514	0.580	0.769	0.966	1.229	1.476	1.900	2.334	2.878	3.521	5.224
6	0.377	0.528	0.635	0.792	0.981	1.232	1.525	1.957	2.371	3.137	4.205	5.297
7	0.379	0.530	0.665	0.799	0.982	1.232	1.575	1.959	2.418	3.189	4.222	5.759
8	0.387	0.538	0.680	0.803	1.001	1.281	1.588	1.984	2.429	3.236	4.270	6.176
9	0.428	0.548	0.684	0.820	1.020	1 344	1.595	2.049	2.444	3.263	4.295	6.271
10	0.437	0.549	0.688	0.838	1.045	1.354	1.687	2.139	2.502	3.297	4.617	7.711
	0.358	0.511	0.617	0.776	0.955	1.220	1.518	1.920	2.336	2.949	3.859	5.552

TABLE No. 16.

Nashua River at Clinton. 119 Square Miles.

Comparison of available flow averaged by three different methods.

Chronologically.			Order of Magnitude by Years.			Order of Magnitude of Whole Term.		
Month.	Flow.	Flow Available.	No.	Flow.	Flow Available.	No.	Flow.	Flow Available.
September.....	0.669	0.669	1	0.436	0.436	1	0.358	0.358
August.....	0.805	0.794	2	0.592	0.579	2	0.511	0.498
July.....	0.824	0.809	3	0.734	0.697	3	0.617	0.587
October.....	0.899	0.866	4	0.930	0.844	4	0.776	0.706
November	1.250	1.100	5	1.041	0.918	5	0.955	0.825
June.....	1.418	1.198	6	1.207	1.015	6	1.220	0.980
January.....	1.819	1.398	7	1.399	1.111	7	1.518	1.129
May	1.951	1.453	8	1.815	1.285	8	1.920	1.296
February.....	2.167	1.525	9	2.473	1.504	9	2.337	1.436
December	2.251	1.546	10	2.842	1.596	10	2.949	1.580
April	3.823	1.808	11	3.874	1.768	11	3.859	1.740
March	4.696	1.881	12	5.229	1.881	12	5.552	1.881

TABLE No. 17.

MERRIMAC RIVER AT LAWRENCE. DRAINAGE AREA, 4 452 SQUARE MILES.

1890 to 1896. Weekly data arranged in order of magnitude for full term in second-feet per square mile.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0.271	0.386	0.414	0.434	0.459	0.476	0.491	0.500	0.515	0.534	0.548	0.565	0.581	0.602	0.615	0.640	0.663	0.689
2	0.284	0.387	0.415	0.434	0.461	0.477	0.491	0.501	0.516	0.534	0.549	0.565	0.581	0.602	0.617	0.641	0.663	0.692
3	0.325	0.390	0.415	0.437	0.461	0.477	0.492	0.501	0.517	0.535	0.550	0.566	0.582	0.604	0.618	0.642	0.665	0.692
4	0.335	0.393	0.416	0.437	0.461	0.479	0.492	0.502	0.519	0.536	0.551	0.568	0.583	0.604	0.619	0.644	0.665	0.693
5	0.339	0.394	0.418	0.439	0.463	0.480	0.493	0.505	0.519	0.536	0.553	0.569	0.584	0.604	0.621	0.644	0.666	0.694
6	0.342	0.396	0.419	0.440	0.465	0.482	0.493	0.505	0.521	0.536	0.553	0.570	0.589	0.605	0.624	0.645	0.668	0.695
7	0.344	0.396	0.420	0.440	0.466	0.482	0.493	0.505	0.521	0.536	0.553	0.570	0.591	0.607	0.624	0.645	0.669	0.699
8	0.345	0.397	0.422	0.440	0.466	0.482	0.494	0.506	0.524	0.536	0.555	0.571	0.591	0.607	0.625	0.648	0.672	0.701
9	0.359	0.399	0.422	0.441	0.466	0.483	0.494	0.508	0.524	0.539	0.555	0.573	0.597	0.607	0.626	0.652	0.673	0.704
10	0.364	0.401	0.423	0.444	0.467	0.487	0.494	0.508	0.525	0.541	0.555	0.574	0.597	0.608	0.626	0.654	0.676	0.706
11	0.368	0.403	0.423	0.446	0.467	0.487	0.495	0.508	0.525	0.541	0.556	0.574	0.598	0.609	0.629	0.655	0.677	0.706
12	0.369	0.405	0.423	0.447	0.468	0.488	0.495	0.508	0.526	0.542	0.556	0.575	0.600	0.613	0.629	0.655	0.679	0.707
13	0.372	0.405	0.424	0.449	0.469	0.489	0.496	0.512	0.529	0.543	0.557	0.575	0.600	0.613	0.634	0.656	0.681	0.707
14	0.374	0.406	0.430	0.451	0.469	0.489	0.498	0.513	0.530	0.544	0.557	0.578	0.601	0.614	0.635	0.657	0.685	0.710
15	0.380	0.406	0.431	0.455	0.470	0.490	0.498	0.514	0.532	0.546	0.557	0.578	0.601	0.614	0.636	0.659	0.686	0.711
16	0.383	0.409	0.432	0.457	0.470	0.490	0.499	0.514	0.533	0.546	0.560	0.578	0.601	0.614	0.636	0.660	0.687	0.712
17	0.385	0.411	0.432	0.458	0.472	0.491	0.500	0.515	0.533	0.548	0.564	0.579	0.601	0.615	0.639	0.660	0.688	0.715
Average,	0.349	0.399	0.422	0.444	0.466	0.484	0.494	0.507	0.524	0.540	0.555	0.572	0.593	0.608	0.627	0.650	0.674	0.702

TABLE No. 18.

MERRIMAC RIVER AT LAWRENCE. DRAINAGE AREA, 4 452 SQUARE MILES.

1890 to 1906. Weekly data arranged in order of magnitude for full term.

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	0.716	0.743	0.763	0.790	0.826	0.865	0.899	0.934	0.991	1.045	1.114	1.160	1.231	1.300	1.355	1.420	1.485	1.577
2	0.720	0.743	0.764	0.792	0.837	0.865	0.900	0.935	0.994	1.046	1.118	1.161	1.234	1.302	1.359	1.421	1.486	1.577
3	0.721	0.744	0.766	0.794	0.839	0.867	0.902	0.947	0.999	1.053	1.121	1.161	1.235	1.307	1.367	1.423	1.486	1.580
4	0.721	0.744	0.772	0.795	0.841	0.869	0.902	0.951	1.000	1.054	1.123	1.163	1.244	1.313	1.367	1.429	1.490	1.583
5	0.722	0.745	0.773	0.795	0.845	0.870	0.903	0.953	1.001	1.067	1.126	1.169	1.249	1.313	1.370	1.430	1.493	1.590
6	0.722	0.745	0.773	0.795	0.847	0.874	0.903	0.966	1.004	1.073	1.127	1.173	1.251	1.316	1.375	1.433	1.502	1.590
7	0.724	0.751	0.774	0.800	0.848	0.878	0.910	0.968	1 007	1.079	1.130	1.181	1.252	1.316	1.387	1.438	1.504	1.592
8	0.726	0.752	0.775	0.802	0.849	0.879	0.910	0.971	1.009	1.083	1.135	1.195	1.260	1.319	1.394	1.442	1.517	1.595
9	0.726	0.753	0.780	0.802	0.853	0.886	0.911	0.972	1.015	1.086	1.138	1 197	1.268	1.319	1.394	1.443	1.519	1.596
10	0.727	0.755	0.780	0.807	0.855	0.886	0.913	0.972	1.017	1.092	1.142	1.198	1.272	1.319	1.398	1.444	1.530	1.597
11	0.729	0.756	0.781	0.809	0.858	0.888	0.915	0.973	1.025	1.095	1.142	1.204	1.275	1.319	1.400	1.452	1.532	1.600
12	0.729	0.756	0.781	0.809	0.859	0.888	0.925	0.974	1.029	1.098	1.143	1.204	1.287	1.327	1.412	1.457	1.536	1.604
13	0.730	0.756	0.783	0.809	0.859	0.888	0.925	0.977	1.034	1.098	1.144	1.208	1.291	1.328	1.413	1.458	1.545	1.608
14	0.731	0.757	0.783	0.810	0.861	0.889	0.928	0.980	1.035	1.101	1.148	1.210	1.292	1.333	1.414	1.477	1.545	1.608
15	0.731	0.758	0.784	0.813	0.863	0.891	0.928	0.985	1.036	1.108	1.148	1.211	1.295	1.335	1.414	1.477	1.548	1.615
16	0.733	0.759	0.788	0.821	0.864	0.894	0.928	0.989	1.039	1.110	1.149	1.218	1.296	1.344	1.416	1.477	1.548	1.619
17	0.740	0.760	0.788	0.825	0.864	0.895	0.929	0.991	1.041	1.110	1.157	1.222	1.296	1.353	1.417	1.485	1.569	1.622
Average	0.726	0.752	0.777	0.804	0.851	0.881	0.914	0.961	1.016	1.082	1.136	1.190	1.266	1.321	1.391	1.447	1.520	1.597

TABLE No. 19.

MERRIMAC RIVER AT LAWRENCE. DRAINAGE AREA, 4 452 SQUARE MILES.

1890 to 1906. Weekly data arranged in order of magnitude for full term.

	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1	1.626	1.785	1.895	2.017	2.128	2.280	2.431	2.565	2.786	3.017	3.323	3.639	4.199	4.519	5.088	5.765
2	1.634	1.802	1.902	2.019	2.133	2.283	2.432	2.568	2.823	3.053	3.356	3.661	4.217	4.562	5.095	5.908
3	1.634	1.804	1.903	2.026	2.169	2.289	2.440	2.571	2.830	3.084	3.384	3.681	4.244	4.565	5.111	5.941
4	1.639	1.825	1.928	2.048	2.173	2.294	2.443	2.598	2.832	3.092	3.389	3.683	4.261	4.608	5.122	6.310
5	1.686	1.831	1.929	2.049	2.202	2.319	2.457	2.619	2.853	3.096	3.415	3.690	4.278	4.636	5.168	6.364
6	1.687	1.833	1.929	2.050	2 203	2.322	2.461	2.631	2.865	3.103	3.424	3.747	4.291	4.637	5.242	6.426
7	1.697	1.846	1.935	2.055	2.204	2.350	2.472	2.676	2.891	3.119	3.433	3.762	4.300	4.681	5.267	6.436
8	1.701	1.851	1.941	2.056	2.205	2.371	2.473	2.687	2.915	3.123	3.445	3.835	4.320	4.701	5.270	6.470
9	1.702	1.858	1.943	2.060	2.217	2.372	2.486	2.701	2.930	3.124	3.446	3.894	4.339	4.718	5.274	6.767
10	1.708	1.861	1.946	2.075	2.226	2.376	2.502	2.714	2.953	3.134	3.454	3.942	4.342	4.723	5.307	7.260
11	1.716	1.874	1.969	2.077	2.231	2.377	2.507	2.723	2.955	3.147	3.476	3.944	4.375	4.723	5.335	7.361
12	1.718	1.883	1.969	2.078	2.231	2.388	2.508	2.726	2.982	3.148	3.478	3.950	4.378	4.734	5.340	7.891
13	1.725	1.885	1.981	2.091	2.239	2.391	2.509	2.729	2.986	3.150	3.481	3.966	4.468	4.837	5.387	7.900
14	1.734	1.889	1.990	2.098	2.246	2.392	2.530	2.735	3.005	3.193	3.493	3.969	4.469	4.884	5.392	8.237
15	1.759	1.890	1.993	2.104	2.254	2.394	2.531	2.746	3.014	3.231	3.510	3.981	4.471	5.007	5.530	8.622
16	1.764	1.892	2.005	2.115	2.259	2.400	2.539	2.751	3.014	3.234	3.520	4.060	4.475	5.044	5.585	9.036
17	1.781	1.895	2.014	2.116	2.270	2.406	2.558	2.781	3.015	3.303	3.529	4.168	4.511	5.061	5.725	9.043
Av.	1.701	1.853	1.951	2.067	2.211	2.353	2.487	2.678	2.921	3.138	3.444	3.857	4.349	4.744	5.308	7.161

TABLE No. 20.

MERRIMAC AT LAWRENCE. 1890 TO 1906.

Second-feet per square mile.

Development.	Average Available.	Weeks.		Available per ct. of Development.
		Short.	Full.	
0.3	0.300	0	52	100
0.4	0.399	2	50	100
0.5	0.492	7	45	98
0.6	0.572	13	39	95
0.7	0.642	17	35	92
0.8	0.705	21	31	88
0.9	0.762	24	28	85
1.0	0.813	26	26	81
1.1	0.861	28	24	78
1.2	0.906	30	22	76
1.3	0.947	31	21	73
1.4	0.986	33	19	70
1.5	1.022	34	18	68
1.6	1.055	36	16	66
1.7	1.085	36	16	64
1.8	1.114	37	15	62
1.9	1.142	38	14	60
2.0	1.168	39	13	58
2.1	1.193	40	12	57
2.2	1.215	41	11	55
2.3	1.236	41	11	54
2.4	1.256	42	10	52
2.5	1.275	43	9	51
2.6	1.292	43	9	50
2.7	1.309	44	8	48
2.8	1.325	44	8	47
2.9	1.340	44	8	46
3.0	1.354	45	7	45
3.1	1.367	45	7	44
3.2	1.380	46	6	43
3.3	1.391	46	6	42
3.4	1.400	46	6	41
3.5	1.413	47	5	40
3.6	1.423	47	5	39
3.7	1.432	47	5	38
3.8	1.442	47	5	37
3.9	1.451	48	4	37
4.0	1.458	48	4	36
4.1	1.466	48	4	36
4.2	1.474	48	4	35
4.3	1.482	48	4	35
4.4	1.488	49	3	34
4.5	1.494	49	3	33
4.6	1.500	49	3	33
4.7	1.506	49	3	32
4.8	1.510	50	2	32
4.9	1.514	50	2	31
5.0	1.518	50	2	30

A GLANCE AT THE WATER SUPPLY OF PHILADELPHIA.

BY JOHN C. TRAUTWINE, JR., CIVIL ENGINEER, PHILADELPHIA, PENN.

[*Read September 23, 1903.*]

INTRODUCTION.

Now that the New England Water Works Association has ventured so far out of its latitude as to hold its convention in a suburb of Philadelphia, it seems not inappropriate that some mention should be made of a water-works enterprise the inception and progress of which have greatly exercised some of the inhabitants of that city.

I have been asked to present a statement of the " progress and present condition " of the Philadelphia filtration plant; but, in order to do this satisfactorily, it may be well to give, first, an outline of the works in general.

With the same object in view, I find myself tempted to volunteer also a bit of the *history* of the Philadelphia water supply, even at the risk of indulging in some personal reminiscences, and thus fighting some of my own battles o'er again.

EARLY CONDITIONS.

The public water supply of Philadelphia has always been drawn either from the Schuylkill River alone or from the Schuylkill and Delaware rivers, the Schuylkill being a tributary of the Delaware and entering that stream at the lower end of the city.

The Schuylkill rises in the anthracite coal regions of Pennsylvania, about 100 miles above Philadelphia, and has a watershed of about 1 900 square miles. The Delaware rises in the southeastern part of New York state, a little north of Port Jervis, where New York, New Jersey, and Pennsylvania meet. Its watershed, above Philadelphia, has about 8 000 square miles, and is about 180 miles long, from north to south, and in general from 20 to 70 miles wide from east to west.

Prior to 1854 the city of Philadelphia covered only about two square miles, being comprised within the nearly rectangular area bounded by the Delaware River on the east, by the Schuylkill

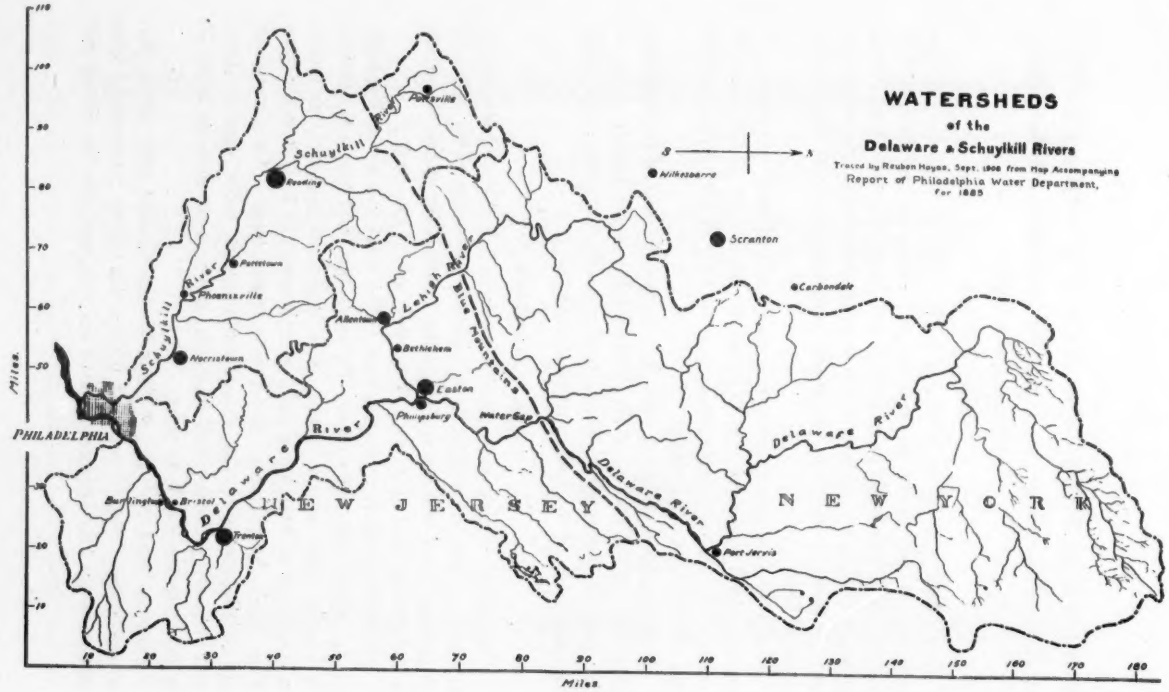

WATERSHEDS
of the
Delaware & Schuylkill Rivers
Traced by Reuben Haupt, Sept. 1906 from Map Accompanying
Report of Philadelphia Water Department,
For 1885
S
N
Wilkesbarre
Scranton
Carbondale
Pottsville
Reading
Schuylkill River
Pottstown
Phoenixville
Norristown
PHILADELPHIA
Allentown
Lehigh River
Bethlehem
Blue Mountains
Easton
Phillipsburg
Water Gap
Delaware River
Delaware River
Delaware River
Bristol
Trenton
Port Jervis
NEW JERSEY
NEW YORK
Miles.
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
Miles.

FIG. 1.

River on the west, by Vine Street on the north, and (appropriately) by South Street on the south. The distance between rivers is about two miles, and the distance between Vine and South streets is about one mile. Beyond these limits lay the "districts" of Kensington, Northern Liberties, Spring Garden, etc., on the north; Southwark, Moyamensing, etc., on the south.

About the close of the eighteenth century, say 1795 to 1800, the city was repeatedly scourged by yellow fever, which drove its well-to-do inhabitants to the adjacent hills or to distant places and left the poor in town to bear it as best they could.

Even in those early days, some connection was suspected between the water supply and the spread of such diseases, for these visitations of yellow fever gave rise to active agitation for an improved and public water supply, the supply hitherto having been taken from wells and cisterns.

Scott's Geographical Dictionary, published in 1805, says: "The water of those parts of the city which are most thickly inhabited . . . had become so corrupt by the multitude of sinks and other receptacles of impurity, as to be almost unfit to be drank."

As in later days, all manner of rival schemes were brought forward and were soon in lively conflict. Among these stood out prominently the proposition of the Delaware and Schuylkill Canal Company, which proposed to tap the Schuylkill River at Norristown, fourteen miles above the city, and to construct a navigation canal from that point down the east bank of the Schuylkill River to Fairmount, and thence across the country, just north of the city, to the Delaware. This concern proposed to tap its main canal at Broad Street and to bring a branch canal, for water supply, to a pond or reservoir to be constructed on "Broad Street extended," at what is now Callowhill Street, just north of the then city limits, whence another canal was to lead down Broad Street, across the city, to South Street, and to supply canals, or at least gutters, on the east and west streets. This was to be a gravity supply, in the true and extreme sense of the word, the citizens being expected to take their supplies by main force from these surface canals. In the canal company's proposition, the introduction of a supply under pressure was reserved for future discussion.

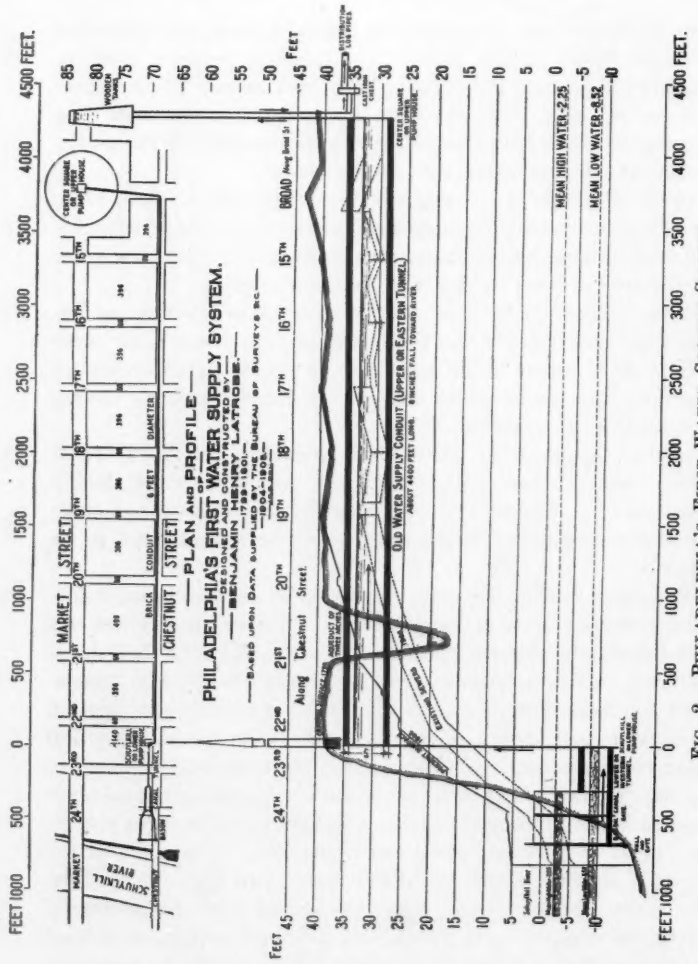

PLAN AND PROFILE
OF
PHILADELPHIA'S FIRST WATER SUPPLY SYSTEM.
DESIGNED AND CONSTRUCTED BY
BENJAMIN HENRY LATROBE.
1799-1801.
BASED UPON DATA SUPPLIED BY THE BUREAU OF SURVEYS &c.
1904-1908.
MARKET STREET
CHESTNUT STREET
SCHUYLKILL RIVER
Along Chestnut Street.
OLD WATER SUPPLY CONDUIT (UPPER OR EASTERN TUNNEL)
MEAN HIGH WATER-2.25
MEAN LOW WATER-0.52
FEET 1000 500 0 500 1000 1500 2000 2500 3000 3500 4000 4500 FEET.
FEET 45 40 35 30 25 20 15 10 5 0 -5 -10

FIG. 2. PHILADELPHIA'S FIRST WATER SUPPLY SYSTEM.
Devised and Constructed by Benjamin Henry Latrobe, 1799-1801.
PLAN AND PROFILE.

Another prominent project was that of Benjamin Franklin, who left a sum of money to be expended in bringing the waters of the Wissahickon Creek to the city.

Finally, however, the project of Benjamin Henry Latrobe (who

refers to himself as being " the only successful architect and engineer " in America at that time) prevailed and was carried to execution in 1801. (See portrait, Plate I.)

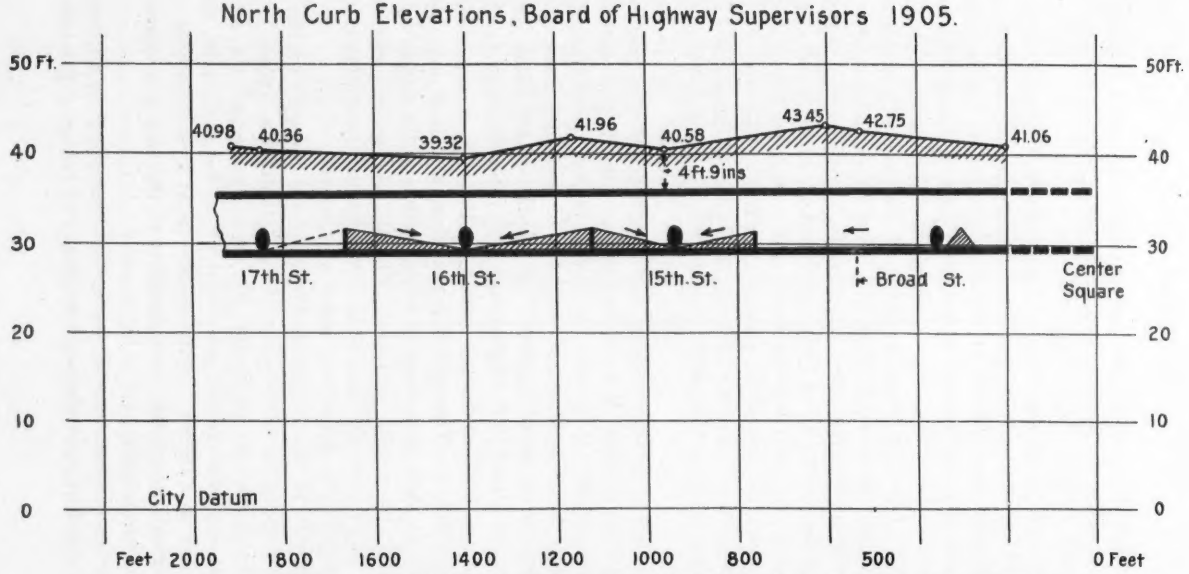
The Schuylkill was tapped on the east side, at Chestnut Street, and its waters were led, by gravity, to the pump well of a steam station located upon the site of a British redoubt, on high ground on the north side of Chestnut Street, just west of Twenty-Second Street, or about one block east of Chestnut Street bridge. (Plate II, Fig. 1.) Here the surplus power of the engine was rented out to run a rolling and slitting mill in an adjacent building.

This station lifted the water into a six-foot brick conduit, which ran along the north side of Chestnut Street to Broad Street, and there turned abruptly and ran northward to a second station in Center Square, the site of the present City Hall. Here the water was again pumped, this time into overhead tanks, whence it flowed through log pipes to the distribution. (See Fig. 2, and Plates II and III.)

West of about Seventeenth or Eighteenth Street, the grading down of Chestnut Street has removed the old conduit, but east of Seventeenth Street it is still in place. During comparatively recent years it has been used for purposes of sewerage, a low dam being constructed across it, about the middle of each block, and false bottoms placed in it, sloping each way from the dams to the sewers on the north-and-south streets at the ends of the block, as shown in Fig. 3. The conduit (so much as remained of it) was thus made to serve as a series of short feeders to the sewers running north and south. In April, 1906, the old conduit was cut through, where the City Hall looks down South Broad Street, by the excavations for the subway since constructed.

In a report to the American Philosophical Society, in 1803, Latrobe mentions the two engines of the Philadelphia system, two in New York, and one in Boston, five in all, as being " the only engines of any considerable powers which, as far as I know, are now at work in America." This enables us to form some idea of the prodigiousness of the work involved in the tiny first waterworks of Philadelphia.

The earliest boilers were of wood, but these were shortly followed by cast iron, and afterward by plate iron boilers. The prin-



OLD 6FT. BRICK AQUEDUCT IN BROAD AND CHESTNUT ST'S. AS USED FOR SEWERAGE.

FIG. 3.

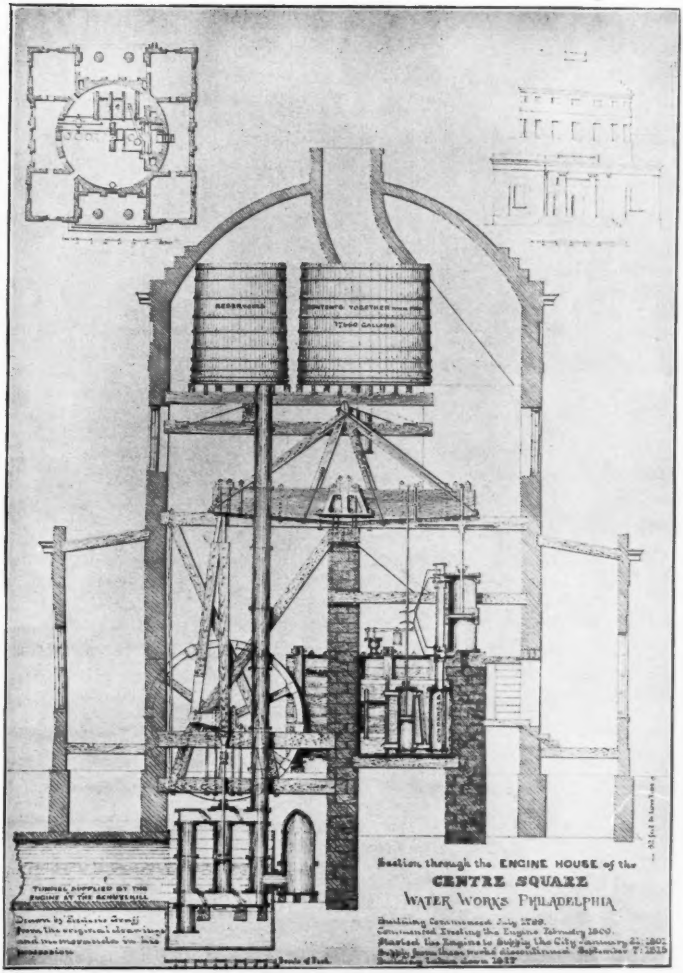
BENJAMIN HENRY LATROBE,

Engineer of Philadelphia's first Water Works, 1799–1801.

FIG. 1. SCHUYLKILL PUMPING STATION, PHILADELPHIA.
BUILT 1799–1801.

(From a water-color sketch by Mumford.)

FIG. 2. CENTER SQUARE PUMPING STATION, PHILADELPHIA.
Built 1799–1801, on site of present City Hall, Broad and Market streets. Removed 1827.



CENTER SQUARE PUMP HOUSE, PHILADELPHIA. 1799–1801.
VERTICAL SECTION.

(The distortion of the two upper figures is due to unavoidable difficulties in photographing.)

cipal rods, beams, and shafts of the engines were also of wood, as were also the tanks, and, as we have seen, the distributing pipes. Some of the details of these boilers and engines are shown in Fig. 4.

The contractor for the engines was Nicholas I. Roosevelt, of Soho, N. J., a brother to President Roosevelt's grandfather. Nicholas, who afterward married Latrobe's daughter, was evidently a heavy loser through the contract, and the city suffered correspondingly, the " Watering Committee " finding it impossible to keep him up to time with his work. In particular, Mr. Roosevelt undertook to provide the Schuylkill engine with an " index " (probably a revolution counter). One annual report after another remarks that this " index " is not yet in place, and finally the mention of it is dropped. (See portrait, Plate IV.)

On the other hand, the city councils, then as now, found it possible to act the part of a thorn in the flesh of the engineer. Nicholas was practically bankrupted by delays in payments, and in one of his letters Latrobe writes, " First the sub-committee of the Watering Committee must assent to an agreement, then comes the Watering Committee itself, then the Common Council and the Select Council, — all avaricious, unjust, ignorant, and proud."

These first water works were completed and put in operation in 1801, but they gave most unsatisfactory service; and, the conditions having become intolerable, the old pumping stations and the conduit were abandoned in 1815, and the same distribution system was supplied by steam pumps (including one by Oliver Evans) at Fairmount, which pumped into a reservoir on the top of the rocky Fairmount hill. This reservoir, since greatly enlarged, but still one of the smaller reservoirs, and the old steam pump house, are still standing.

About 1820, a dam and breast wheels were constructed at Fairmount and the steam engines at that point abandoned.

The Fairmount works were constructed by Fred. Graff, Sr. (see portrait, Plate IV), who had been Latrobe's assistant from the beginning, and who was for many years in charge of the water works, as was his son, Fred. Graff, Jr., after him.

At the time of their completion, the Fairmount water works were one of the wonders of the world, and most of my contemporaries

Figures accompanying "First Report of Benjamin H. Latrobe, to the American Philosophical Society, held at Philadelphia; in answer to the enquiry of the Society of Rotterdam, 'Whether any, and what improvements have been made in the construction of Steam-engines in America.'"

American Philosophical Transactions
Vol. 6, pp. 89 &c

May 20, 1803.

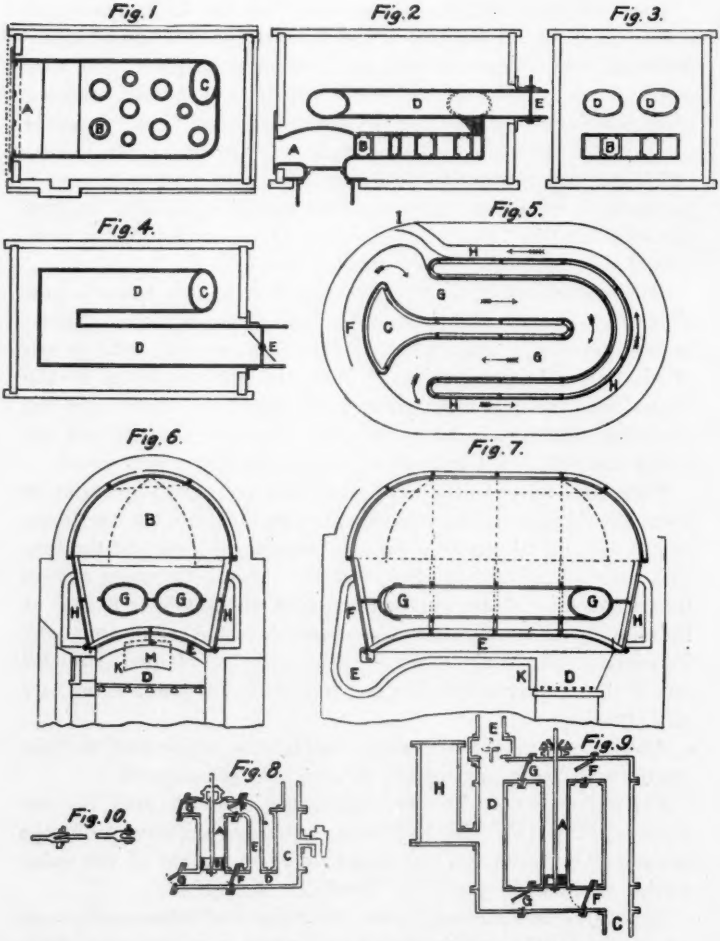


FIG. 4. BOILERS AND ENGINES, PHILADELPHIA'S FIRST WATER WORKS, 1799–1801.

(See opposite page for description of figures.)

will remember how they figured, along with Girard College, in the descriptions of Philadelphia in the school geographies, even as late as the fifties.

In 1851 the first turbine was constructed at Fairmount, and this remained the only turbine until 1867, between which and 1874 all the breast wheels were abandoned and succeeded by six new turbines, making seven in all. This Fairmount plant supplied the entire city proper between Vine and South streets, and, under contract, some portions of the adjacent districts.

In 1854 the city increased its area from 2 to 130 square miles (its present dimensions) by taking in the outlying "districts" and all the rest of Philadelphia County, making the city and county coterminous.

In the meantime, the adjacent districts of Kensington and Spring Garden had constructed steam pumping stations of their own, the Kensington works taking water from the Delaware, and the Spring Garden works from the Schuylkill. With consolidation, these works were taken over by the city, and thereafter the water supply system of the consolidated city grew rapidly.

RECENT CONDITIONS.

Prior to the inauguration of the present filtration system, that is to say, about ten years ago, the works consisted of six pumping stations, five on the Schuylkill and one on the Delaware, those on the Schuylkill being located on the east, or left, bank of the river, except the Belmont station, which supplied that portion of the city lying west of the river. About 90 per cent. of all the water pumped was then taken from the smaller stream, the Schuylkill.

DESCRIPTION OF SMALL FIGURES MAKING UP FIG. 4.

FIGS. 1, 2, 3, 4. Wooden Boilers.
- Fig. 1. Horizontal section through A B, Fig. 2.
- Fig. 2. Vertical longitudinal section at A, Fig. 1.
- Fig. 3. Vertical cross section at D, Fig. 2.
- Fig. 4. Horizontal section through D, Fig. 2.

FIGS. 5, 6, 7. Cast Iron Boilers.
- Fig. 5. Horizontal section through G, Fig. 7.
- Fig. 6. Vertical cross section through G, Fig. 7.
- Fig. 7. Vertical longitudinal section through B D, Fig. 6.

FIG. 8. Air Pump, double acting.
FIG. 9. Main Pump, water end, double acting.
FIG. 10. Braces for cast-iron boilers.

All of the stations, except the one at Fairmount, were operated by steam, and all pumped normally to open, elevated reservoirs, whence the water flowed, by gravity, into the distribution.

It frequently happened, however, that the pumps were unable to keep the reservoirs supplied against the enormous draft (due partly to the use of water, but much more largely to waste), and at such times it became necessary to cut off the reservoirs and to resort to direct pumpage. The dirty river water was then sent direct into our dwellings, without even the benefit of a day or two of sedimentation.

There were also three or four high-service stations, pumping to standpipes, and supplying small districts at elevations too high to be reached by the main pumping stations or supplied from the reservoirs.

The Roxborough station, that farthest up the Schuylkill, raised its water to an elevation of about 400 feet; the Fairmount, or lowest station, about 100 feet.

The Schuylkill river flows through prosperous agricultural and manufacturing districts, with numerous large and thriving manufacturing towns along its banks; so that, although cut off, by the Fairmount dam, from the major part of the city's own pollution, its waters had, long before the present filtration works were designed, become wholly unfit for household use, to say nothing of the fact that each flood in the river brought down, first, the new red shale mud from the districts near the city, and, a day or two later, the anthracite coal dust which had been stored in the navigation dams in the upper portion of the stream.

The Delaware, on the other hand, a larger stream, and flowing through a less densely populated district, was unprotected, by any dam, from the city's own pollution, which traveled upstream with every flood tide.

Notwithstanding this, no attempt at purification of the water had been made. The entire city was supplied with the same fluid which is now furnished to the central business and residence districts. With my apologies to those good people who hold that we should speak only good of our own town, I venture to assert that the conditions were ripe for improvement.

NICHOLAS I. ROOSEVELT, BROTHER OF PRESIDENT ROOSEVELT'S GRANDFATHER, AND BUILDER OF THE TWO STEAM PUMPING ENGINES OF PHILADELPHIA'S FIRST WATER WORKS.

FREDERICK GRAFF, ASSISTANT TO B. H. LATROBE, AND AFTERWARD CHIEF ENGINEER OF PHILADELPHIA WATER WORKS.

He designed and built the steam-power, and, later, the water-power works at Fairmount.

PLATE IV.

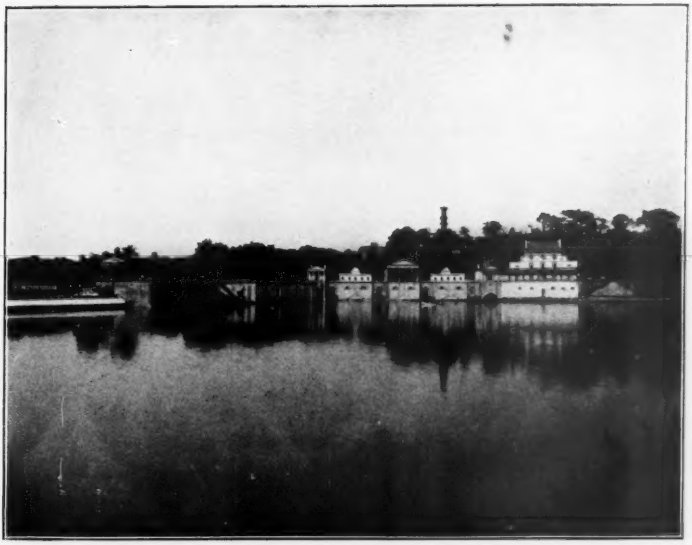


FIG. 1. FAIRMOUNT WATER WORKS, PHILADELPHIA.

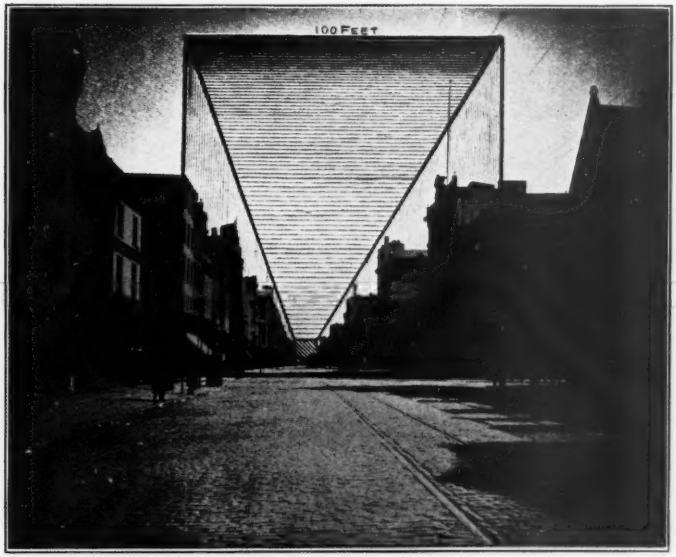


FIG. 2. 250 MILLION GALLONS.

(100 feet square, 3,300 feet long.)

MARKET STREET, LOOKING EAST FROM SEVENTH STREET TO DELAWARE RIVER.

Not only was the quality of the water atrocious, but the supply was ridiculously inadequate, and that solely because the people gloried in throwing away, unused, at least two thirds of all the water pumped.

With the greatest water-pumping plant on earth, running night and day, straining itself to the point of destruction, and pumping something like two hundred gallons per capita daily, a large portion of the city was constantly complaining (and with excellent cause) of the insufficiency of the supply, — the pressure, over much of the area, being insufficient to carry the water above the second floor; and all because one man in five was robbing the other four, and the four insisted that the robber should not be interfered with.

The average pumpage, deduced from plunger displacement and no doubt considerably exaggerated, was about 250,000 000 gallons per day. Even allowing for exaggeration, it probably approximated at least 200 000 000 gallons.

Market Street is one hundred feet wide between house-lines; and 250 000 000 gallons would fill Market Street, to a depth of one hundred feet, from the Delaware river to 7th Street, forming a square prism one hundred feet square and three thousand feet long, as shown on Plate V, Fig. 2.

During the agitation respecting the method of improvement of the water supply, a certain homeopathic physician, apparently well informed on many subjects, remarked, in one of his discourses in eulogy of the scheme in question, that " the people of Philadelphia would never submit to having their water doled out to them by the pint."

In order to show what ballast there was in this learned remark, I had three cubical frames prepared, covered with white muslin, and photographed. The largest of these frames was a 10-foot cube, containing, therefore, 1 000 cubic feet, which the city was then selling, by meter, for " thirty cents "; the next contained 1 000 gallons, or four cents' worth, while the smallest contained 1 000 pints, or one cent's worth. These 1 000 pints will furnish six comfortable baths.

In those degenerate days, our city fathers, and the statesmen who controlled the city's operations, were intent chiefly upon

obtaining and holding the control of things, and the sanitary condition of the city was a matter of quite secondary importance.

Although communities all about us were loudly proclaiming the benefits to be derived from the use of the water meter, our people were so densely and persistently ignorant of the matter that those who were most actively but unofficially interested in the improvement of the water supply, were ready to suppress abruptly any one who mentioned the water meter, and thereby threatened to arouse public opposition to the whole scheme of water improvement.

Under the circumstances, it is not strange that there was lively agitation for improvement. Commission after commission had studied the subject and made recommendations, most or all of which were ignored; and, as happened a hundred years before, all manner of rival schemes were actively advocated.

At this juncture, the writer found himself in charge of the Bureau of Water. He gave careful study to the subject of the improvement of the supply, both as to quantity and as to quality.

As to quantity, the result of course was that he persistently advocated the use of the water meter, and thereby not only alienated the politicians, who saw their welfare rather in the construction of unlimited pumps and "resavoys," but also lost the sympathy and coöperation of the public-spirited people who were forming themselves into associations for water improvement, and who were fearful lest all projects for improvement would be dashed by the mention of the ominous word "meter"; and this notwithstanding the fact that the city's finances at that time were (or were given out to be) such that the city could not possibly find means for the construction of works for the purification of the enormous quantities then used and wasted.

As to quality, the writer's studies had impressed him most forcibly with the facts (1) that filtration was the indicated solution of our problem; and (2) that the science of water purification was then in its infancy, that each supply must, to a great extent, be a law unto itself, and that each community must work out its own salvation with fear and trembling, and without relying slavishly upon the experiences of other communities.

He recognized, too, that the Philadelphia system lent itself admirably to just such experimental work as was required in its case, where the supply was taken from two rivers of quite different characteristics.

The single pumping plant on the Delaware was of moderate dimensions, as were two of those upon the Schuylkill, and he urged that the first step toward the filtration of the entire supply should be the construction of a filtration plant or plants in connection with one or two of these smaller stations, said plants to contain installations of each of the systems then best and most favorably known, in order that these might be tested in actual use and in competition with each other, and that the effects of filtration upon the public health might be tested in those limited districts.

It is needless to say that this scheme, like that for the restriction of waste, found no favor with the politicians in charge, and but little, if any, with the benevolent people who were agitating for improvement, and who insisted that the supply for the whole city must be purified at once. Experiment was taboo, for it meant postponement of completion, which, by the way, has not yet been brought about.

We were told that, if a beginning were made with one or two districts, all the others would be up in arms; yet that is exactly what has been done, and no revolution has resulted. We were asked whether filtration had not then " passed beyond the experimental stage."

Among the various schemes then claiming public attention was a large and well-assorted collection of water-snakes, in the shape of benevolent corporations, each with its champions in the city councils, and each kindly proposing to bring the impoverished city out of its water difficulties.

Notable among these was the Schuylkill Valley Water Company, which proposed filtering Schuylkill water, taken below Reading, and which was getting on swimmingly in councils, with every prospect of going through, when an inconsiderate member threw the fat in the fire by announcing that he had been offered a substantial sum for his vote in favor of the company's ordinance.

That such a trifle could block a scheme of this sort shows that the harmony, which has since reigned in the councils of the domi-

nant political party in our midst, had not then been completely established. Nowadays, any reptile cage placed before councils for approval, contains *but one* specimen, and every councilman knows what are his orders from "the front." In those days, however, the administration found itself opposed by an active and powerful faction, which ruled that all improvement of the water supply must await the inauguration of the succeeding administration which they hoped to, and which they eventually did, control.

The result of this policy is seen in the following comparison of estimates for extensions and improvements, and the corresponding appropriations, during the writer's term of service:

	Estimates.	Appropriations.
For 1896.....	$2,484 150	$0
„ 1897.....	3 339 450	0
„ 1898.....	3 735 050	0

Our boilers and engines were strained to the utmost, night and day, and in some cases disabled; there was no opportunity for thorough repairs; we dared not stop pumping during seasons of muddy water; in spite of all manner of pitiful expedients, we were compelled to cut reservoirs off from the distribution and resort to direct pumpage, in order to avoid emptying the reservoirs completely; and from all sides came loud and well-grounded complaints from citizens who paid for a water supply and did not get it.

Nevertheless, as we have seen, the Schuylkill Valley snake came within an ace of getting its appropriation of fifty millions.

During this time the city fathers passed a resolution providing that chiefs of bureaus should devote the whole (only the whole) of their time to the duties of their offices; and the practice of their honorable bodies seemed to be, when they became apprehensive lest the chief of the water bureau might not be earning his salary, to call for plans and estimates for the filtration of the city's supply. These plans and estimates were furnished, to the best of the bureau's abilities, which, at that time, were represented by an engineering force consisting of the chief draftsman and two or three subordinate draftsmen.

One of these requests for enlightenment mentioned "all the water used by the city," and the writer took advantage of the presence of the word "used" to lay before their honorable bodies

comparative estimates of the cost of filtering (1) all the water used, and (2) all the water used *and wasted*, with results as follows:

ESTIMATED COST OF IMPROVEMENT, 1898.

	For Water Used.	For Water Used. and Wasted.
Extensions.....	$1 000 000	$5 000 000
Filtration plants ..	2 500 000	7 500 000
Meters.....	1 000 000	0
	$4,500 000	$12 500 000

THE PRESENT TRANSFORMATION.

With the advent of the Ashbridge administration, in 1899, the scene shifted. A reassessment of real estate values was made, and the city was said to be in position to borrow practically any sums which might be needed for the improvement of the water supply.

Mayor Ashbridge called in an expert commission, consisting of Messrs. Rudolph Hering, of New York; Samuel M. Gray, of Providence, R. I.; and Joseph M. Wilson, of Philadelphia, who, according to the resolution providing for their appointment, were "to act in conjunction with the chiefs of the Bureaus of Survey and Water."

These gentlemen were, of course, given all needed assistance in their studies, and, after some summer months of hard work, including several all-night sessions by Mr. Hering, their report was published, recommending "the adoption of that project by which the waters of the Schuylkill and Delaware rivers, taken within the city limits, are purified by filtration."

In the body of their report the experts said, "We earnestly recommend the introduction of meters for the city of Philadelphia"; but in their résumé and conclusions the meter was not mentioned, and the deficiency in quantity of supply was ascribed to "the lack of effective pumping machinery and to the insufficient capacity of the distributing system."

The works have cost at least double what would have been required for a lavishly ample supply under proper regulation, and it costs correspondingly to operate them.

Mayor Ashbridge had expressed the wish that the works might

be such as to supply the city for fifty years to come, a view perhaps pardonable in a layman, who could hardly be expected to picture to himself what would be our plight to-day if *our* ancestors of fifty years ago (with the knowledge at their command) had constructed works sufficient for our present supply.

In brief, the report of the experts recommended the retention of all the existing Schuylkill pumping stations and of all but one or two of the smallest reservoirs, the adoption of rapid filtration at East Park reservoir, and of slow filtration for all the rest of the supply, the construction of a large slow-filtration plant and pumping station at Torresdale, and the abandonment of the Lardner's Point pumping station.

Plans were submitted, showing the proposed arrangements at each station and reservoir, and the relations of the several plants to each other and to the entire system.

Like the plan proposed by the experts, that now being carried out follows "that project by which the waters of the Schuylkill and Delaware rivers, taken within the city limits, are purified by filtration." In fact, the report of the experts may be said to form the basis upon which the plant is being constructed; but the two plans differ in certain important details.

The plan now being carried out involves in brief, the abandonment of the Fairmount pumping station, on the Schuylkill, and the construction of the great Delaware pumping station at Lardner's Point, instead of Torresdale; the old works at Lardner's Point to remain in service, this station being supplied with filtered water from the Torresdale filters by the celebrated Torresdale conduit, which formed no part of the plan recommended by the experts. Rapid filtration is discarded, and all the filters are of the covered slow type. The largest reservoir, East Park, will be used chiefly for emergency storage of raw water, and the largest of the old pumping stations, Spring Garden, which supplies East Park reservoir, will be held in reserve.

The long period of storage in the large upper Roxborough reservoir being deemed sufficient, preliminary filters are not used there. They are used, however, at Lower Roxborough and at Belmont, and they will be used at Queen Lane and at Torresdale.

The first preliminary filters, or "scrubbers," built in Philadel-

phia were those at Lower Roxborough reservoir. In them the water flows vertically upward, first through coke and then through sponge.

The next were those at Belmont for the West Philadelphia supply. In these the water flows first horizontally, through coke passing a 2.5-inch mesh; then horizontally again, through coke, passing a 1-inch mesh; then upward through sponge, and finally downward through coke breeze ranging in size from dust to $\frac{3}{8}$ inch.

Both of these plants were designed and built by Mr. P. A. Maignen, and both are working satisfactorily, materially reducing the load on the main filters and permitting a higher rate of filtration through them than would otherwise be compatible with safety.

At Torresdale and at Queen Lane the preliminary filters will consist simply of a series (120 at Torresdale) of rectangular "mechanical" filters, operated without coagulant, and cleansed by reversal of current, and jets of compressed air, as in the filter plants at Little Falls, N. J., and Harrisburg, Penn.

Apart from filtration, the prominent feature of the changes now being made is a reversal of the relation of the Delaware and the Schuylkill as sources of supply, the Delaware being now made the principal source, while the Schuylkill is to be altogether subordinate. Instead of 90 per cent., the new system will take only one third of its supply from the Schuylkill.

For Queen Lane, the experts proposed utilizing the north basin and the larger portion of the south basin for sedimentation, while the remainder of the south basin was to be converted into a clear-water reservoir, and slow filters were to be built upon ground lying just north of the reservoir.

Later, the administration proposed to remove the Queen Lane pumps to the Lardner's Point (Delaware) pumping station and to use the Queen Lane reservoir for the storage of filtered water from Torresdale.

Finally, however, it has been decided to retain the Queen Lane pumping station and to strengthen the foundations of the pumps, to use the entire south basin of the reservoir for sedimentation, and to construct preliminary and slow filters over the north basin, the filtered water to be collected in the lower part of the north

basin immediately under the filters. There will be no pumpage at the reservoir, the water passing by gravity first from the sedimentation basin to the scrubbers, then to the filters, then to the clear water basin, and finally to the distribution. The filters and scrubbers will be supported by concrete columns, piercing the

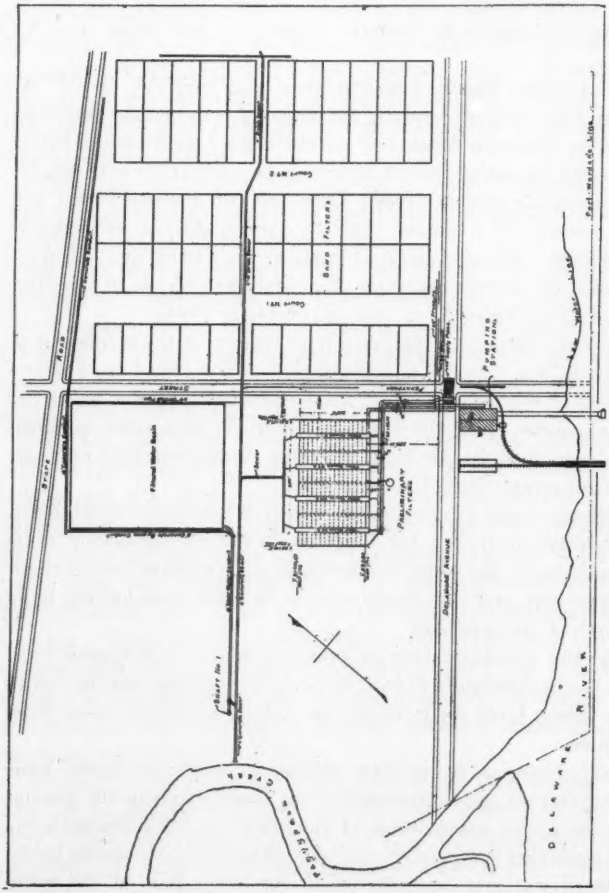


FIG. 5. PLAN OF TORRESDALE FILTER PLANT, SHOWING PUMPING STATION, PRELIMINARY FILTERS, 55 OF THE 65 SLOW FILTERS, FILTERED WATER BASIN, AND BEGINNING OF TORRESDALE CONDUIT.

concrete and clay puddle which form the present floor of the north basin, and resting on rock foundation.

On the Delaware, at Torresdale, two and one-half miles above the former intake at Lardner's Point, a slow filtration plant, believed to be the largest in the world, is now practically completed (see Fig. 5). Here the Delaware water is first lifted by centrifugal pumps to the filters, whence it flows to the adjoining clear water basin, and thence, through the Torresdale conduit, 10 feet 7 inches in diameter and 100 feet below the surface, to the Lardner's Point station, which has been enlarged to many times its old capacity, and which, under the new system, will form by far the largest station for the city's supply, and, it is believed, the largest high-duty pumping station in the world. The new portion of this station will contain twelve new twenty-million gallon pumping engines. When completed, the Torresdale plant will contain 65 filter beds, with a total filtering area of nearly 50 acres, and a preliminary filter plant of 120 rectangular mechanical filter tanks.

Practically, the supply from Lardner's Point will be by direct pumpage of filtered water.

The old Delaware works had but one reservoir, and that a small and defective one, and the great projected Delaware system has also but one small reservoir, and this acts merely to counterbalance the expected inequality between the day and the night demand.

Connected with the Delaware system is one high-service station constructed some ten years ago.

At the risk of advertising an old friend, I will mention that this Wentz Farm high-service station contains one of the few existing d'Auria pumps, another being in operation at the Pleasantville plant which supplies Atlantic City. These pumps are unique in their means for securing high-duty, viz., an oscillating or reciprocating body of water, which acts as a liquid balance-wheel, reversing its direction of motion at each stroke of the pump. The expensive crank and fly wheel are thus dispensed with. The Philadelphia d'Auria was purchased by the Water Bureau in an emergency, and it has since had a checkered career, having been moved about from one station to another and forced to operate generally under unfavorable conditions for which it was not designed. Some years ago it found a resting-place at this little Wentz Farm

station, where it ran for years without a condenser. This lack has been supplied, and Mr. Dunlap tells me that the pump is running well.

It may not be uninteresting to compare Mr. Hill's great Torresdale aqueduct of 1900 with Latrobe's Chestnut Street aqueduct

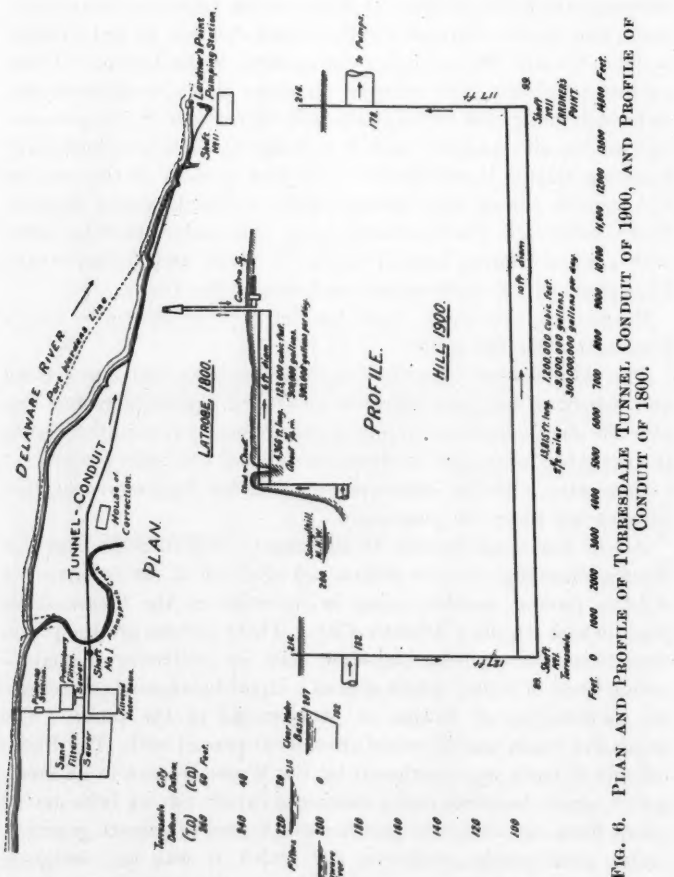


FIG. 6. PLAN AND PROFILE OF TORRESDALE TUNNEL CONDUIT OF 1900, AND PROFILE OF CONDUIT OF 1800.

of 1800. See the accompanying illustration, Fig. 6, which shows both structures at their relative elevations.

	Latrobe.	Hill.
Date	1800	1900
Diameter, feet	6	10
Length, feet	4 366	13 815
Contents, cubic feet	123 000	1 200 000
Capacity, gallons per day	300 000	300 000 000

For convenience of flushing, both aqueducts were given a gentle inclination downward toward their points of beginning. In the Latrobe aqueduct, the flow was by gravity; the slope of the water surface of course producing the flow, notwithstanding the slope of the aqueduct itself in the opposite direction. In Mr. Hill's tunnel, the flow is under pressure, and is caused by the difference in elevation of water surface in the shafts at its two ends.

In 1905 our quiet city was convulsed by a political upheaval. The politicians aroused popular resentment by undertaking a modification of the gas-works lease. Reformers, anxious for improvement, and would-be's, anxious for power and place, seized the opportunity. Mayor Weaver threw in his lot with the new party, threw out his Directors of Safety and of Public Works, and appointed Major Cassius E. Gillette chief of the Bureau of Filtration, to succeed Mr. John W. Hill. Major Gillette, in conjunction with Mr. J. Donald Maclennan, since deceased, reported that, in various ways, the city had been defrauded of some $6 000 000 by the contractors. Thereupon work was stopped for some time, but was afterward resumed, under Major Gillette's charge. With the advent of the present administration, Major Gillette was succeeded by the present chief, Mr. Fred C. Dunlap.

The average daily consumption, during 1907, based largely upon plunger displacement, was 300 000 000 gallons.

The total daily capacity of the works when completed may be stated as 340 000 000 gallons.

The Belmont plant, which supplies all of Philadelphia west of the Schuylkill, has a total nominal capacity of 40 000 000 gallons per day. It has been supplying all, or a part, of this district with filtered water since 1904.

The two Roxborough plants have a combined capacity of 25 000 000 gallons per day. They have been supplying their district with filtered water since 1903.

The Torresdale filter (as yet without scrubbers) in conjunction with the Lardner's Point pumping station (not yet completed) is already supplying the northeastern portion of the city, or say that portion east of Broad Street and north of Spring Garden Street.

The portion of the city not yet supplied with filtered water may be called the central and southern portion, or say the district east of Broad Street and south of Spring Garden Street, and that west of Broad Street and south of Allegheny Avenue.

The works are now filtering from 170 000 000 to 180 000 000 gallons daily. This is about half their intended final capacity and is more than an ample supply for nearly double our present population, but, as we are now wasting at least 100 gallons per capita per day, and using possibly from 50 to 70, I presume that only about one million persons, or about two thirds of our population, are at present supplied with filtered water, while the final supply, of 340 000 000 gallons daily, ample for 5 000 000 people, will be short rations for our one and a half millions.

The important works still to be completed are the preliminary filters at Torresdale, six high-duty pumps at Lardner's Point, and the Queen Lane filters. The preliminary filters at Torresdale are to be completed during the current year, and the Lardner's Point pumps early in 1909, or say ten years after the advent of the Ashbridge administration. The Queen Lane filters have not yet been advertised, and the date of their final completion must depend, to some extent, upon councilmanic appropriations, and these, in turn, of course, upon the grace of his reigning majesty, the Boss.

In round numbers, including engineering and incidental expenses, but exclusive of land damages and experimental and administrative expenses, the changes in the system since 1899, thus far completed or under contract, have cost 26 million dollars, and the work still proposed, but not yet under contract, is estimated to cost 2¼ million more, making a total of 28¼ million, of which 7 million are being expended upon the Schuylkill and 14¼ million

upon the Delaware, 5½ million upon distribution, and 1½ million upon repairs to pumps and stations.

As it will soon be nine years since the writer was officially connected with the Philadelphia water works, he need hardly say that, for most of the information here presented respecting the status and prospects of the works, he is indebted to the present chief of the Bureau of Water, Mr. Fred C. Dunlap, who has extended, to those taking part in this convention, an invitation to visit and inspect the works under his charge.

Any account of the water supply system of Philadelphia would be incomplete without mention of its high-pressure fire service, consisting of a pumping station, at foot of Race Street, Delaware River; four lines of mains, on Race, Arch, Market, and Walnut streets; connecting lines on Second, Fifth, Eighth, and Eleventh streets; and the requisite fire hydrants. Additional connecting lines are now being laid on others of the cross streets. The system extends from the Delaware River to Broad Street. All the mains are of flanged cast-iron pipe.

On Market Street the main is 16 inches in diameter; on Race, Arch, and Walnut streets, 12-inch; and on the cross streets, 8-inch. Chestnut Street was found already so encumbered by underground structures that no attempt was made to lay a fire main there.

The pumping station contains 9 pumps, 7 of 300 horse-power each, and 2 of 150 horse-power each, driven by a gas engine, supplied with gas from the mains of the United Gas Improvement Company.

The maximum fire pressure maintained is 300 pounds per square inch.

The system has been in service for about five years.

AN OLD AQUEDUCT AND ITS DEVELOPMENT.

BY ALBERT L. SAWYER, WATER REGISTRAR, HAVERHILL, MASS.

[*Read September 24, 1908.*]

The water-works system of Haverhill, Mass., is one of the ten oldest in point of organization in the entire area comprised in our Association. There is in our city hardly an institution or business existing to-day that at all approaches it in antiquity of origin, and it is and ever has been most intimately connected with the history and development of the city.

The first municipal water system of which we find record was established at Boston in 1652, consisting of a reservoir about twelve feet square, to which water from springs in the vicinity was conveyed through wooden pipes.

Of the 140 places in Massachusetts having water works in 1890, all but 9 had been built later than 1840, and for the most part since 1870. In the year 1800 there were but 16 places in the United States that had water works, and not one in Canada; and even as late as 1850 there were but 83.

As a matter of record, the sixteen built up to 1800 are enumerated as follows: Boston, 1652; Bethlehem, Penn., 1754; Providence, 1772; Geneva, N. Y., 1787; Salem, 1795; Plymouth, 1796; Hartford, 1797; Portsmouth, Worcester, and Albany, 1798; Peabody, New York City, Morristown, N. J.; Lynchburg, Va., and Winchester, Va., 1799; and Newark, N. J., 1800.

All of these, with the exception of Winchester and Morristown, were built by private companies, but passed into the control of the respective municipalities from time to time up to 1860. The aqueduct at Winchester was built by the municipality; that at Morristown is still owned by a private company.

Of course with a scattered population, where the houses had plenty of surrounding land, wells of pure water were able to amply supply the needs of the people. The denser growth of the towns, the introduction of sanitary plumbing, appendicitis, and the multitude of germs that make life miserable for us to-day, necessitated a corresponding development in the water supply.

It was perfectly natural that the citizens of old Haverhill should have been pioneers, for there are few places that have such an abundance of pure water on all sides, while the situation of the original village, clustered on the waterside, with a natural rise to the three great ponds, offered no problems requiring engineering skill; it was simply to provide an outlet and let the water flow downhill. In fact, we may well suppose that the existence of these natural reservoirs had much influence with the first settlers in the choice of a location for their homes; and certainly there could have been few locations with a more abundant supply of water.

The town of Haverhill, or, as it was originally called, Pentucket, was settled in 1640 by a band of twelve men from Newbury and Ipswich, joined soon after by Rev. John Ward, who became the leader of the settlement, and whose original house is still standing and in the care of the Historical Society. I have a facsimile of the deed from the Indians, Passaqua and Saggahew, in which they made a grant of the lands for the sum of three pounds and ten shillings. As first laid out the town was nearly in the form of a triangle, and included a large portion of the territory now forming the towns of Salem, Atkinson, Hampstead, and Plaistow in New Hampshire, and Methuen in Massachusetts. From the river side the land gradually rises till we come to the large ponds. The nearest, and also the smallest, was Plug Pond, now Lake Saltonstall, and formerly called Ayers Pond from the fact that several people of that name settled near its western end and owned a large part of the adjoining land. This pond has an elevation of 122 feet and covers 70 acres. At the southern extremity was a dam called the "plug dam" in one of the old documents, from which, doubtless, the name of the pond.

Next came Round Pond, with an elevation of 152 feet and containing 80 acres. Round Pond is remarkable from the fact that not a single stream, even of the smallest kind, flows into it, it being supplied, with the exception of the flowage from the surrounding hills, by subterranean springs. Except at one place at the northwest corner, it has a clear, sandy bottom. The natural outlet was toward the southwest into Little River, but the direction of this outlet was long ago artificially changed to secure the surplus water for the mills on the mill brook.

Kenoza Lake, formerly known as Great Pond, was the largest, covering 225 acres, at an elevation of 110 feet, with a large watershed and surrounded by beautifully wooded hills. Its outlet was Fishing River. In 1859 a number of the leading citizens formed a club, purchasing a lot of land on the shore of the lake to be used for picnics and social gatherings.

To John G. Whittier was intrusted the honor of selecting a new name for the pond, and the result was his beautiful poem, "Kenoza," in which he refers to the change of name and to the rare beauty of its natural setting.

"Lake of the pickerel! let no more
The echoes answer back 'Great Pond,'
But sweet Kenoza, from thy shore
And watching hills beyond.

"Kenoza! o'er no sweeter lake
Shall morning break or noon cloud sail;
No fairer form than thine shall take
The sunset's golden veil."

Crystal Lake, formerly called Creek Pond, was situated about three miles away to the west, and covers 159 acres, with an elevation of 152½ feet. Its shores, quite irregular, are beautiful in spots, the water remarkably clear and transparent, and the bottom for the most part even and sandy. Its outlet is Creek Brook, emptying into the Merrimac.

It was not, however, until about 1799 that any steps were taken to bring the water by gravity to the cluster of houses on the banks of the river, in the fork of the roads formed by the intersection of Main and Water streets. Mr. David How, who at the commencement of the last century was one of the leading citizens of the town, was the first to enter on the project of laying a pipe to bring water from Round Pond to his farmhouse. Iron and even clay pipes were then unknown in this country, and the only method for the conveyance of water was by the use of wooden conductors or bored logs. Mr. How's farmhouse was directly back of that portion of our main thoroughfare now occupied by retail business houses. Here, directly in the center of the town, was his house, and around it were clustered his cow yard and pigpens. There

are some old residents who remember the house as it stood in 1835. Mr. How was still living, but old and infirm. His establishment was then regarded as a nuisance; the dilapidated buildings were reeking with filth, and the stench from his pigpens was an annoyance to all in the little village. To this place Mr. How was desirous of bringing water, and with the assistance of neighbors, green pine logs were bored with a two-inch auger, and a line of pipe was laid to Round Pond.

The idea of an aqueduct appears to have appealed to others of the townspeople, and in 1798 the following petition was presented to the legislature then in session in Boston:

To the Honorable the Senate & House of Representatives of the Commonwealth of Massachusetts in General Court Assembled.

The petition of Timothy Osgood of Haverhill in the County of Essex & Commonwealth aforesaid in behalf of himself & others Humbly Shews they have in contemplation sinking an aqueduct taking the water at & from the round pond so called in Haverhill & conveying it through the several streets of said Haverhill for the use & convenience of themselves and others who may be desirous of becoming concerned therein & for their greater convenience & security they pray your Honors would grant to them & such others as my associate with them an act of Incorporation Impowering them by the name of Haverhill Aqueduct Company to convey water into the streets in said Town through aqueducts with all such powers rights & privalidges as the subject matter may render necessary & as in Duty bound will ever pray.

Timothy Osgood *in behalf of himself & others.*

Haverhill Jan^{y} 8th, 1798.

There were, however, some who did not favor the innovation, for we find in the records of the same year that the town's representative, Mr. Nathaniel Marsh, was instructed "to oppose Osgood's petition for an aqueduct to take water from Round Pond." The petition was evidently granted, however, and in 1801 we find in the town records the steps taken for the formation of the company which from that time on furnished the water supply of the town. This petition was referred to a committee, of which Bailey Bartlett, who for several years was sheriff of the county, was chairman,

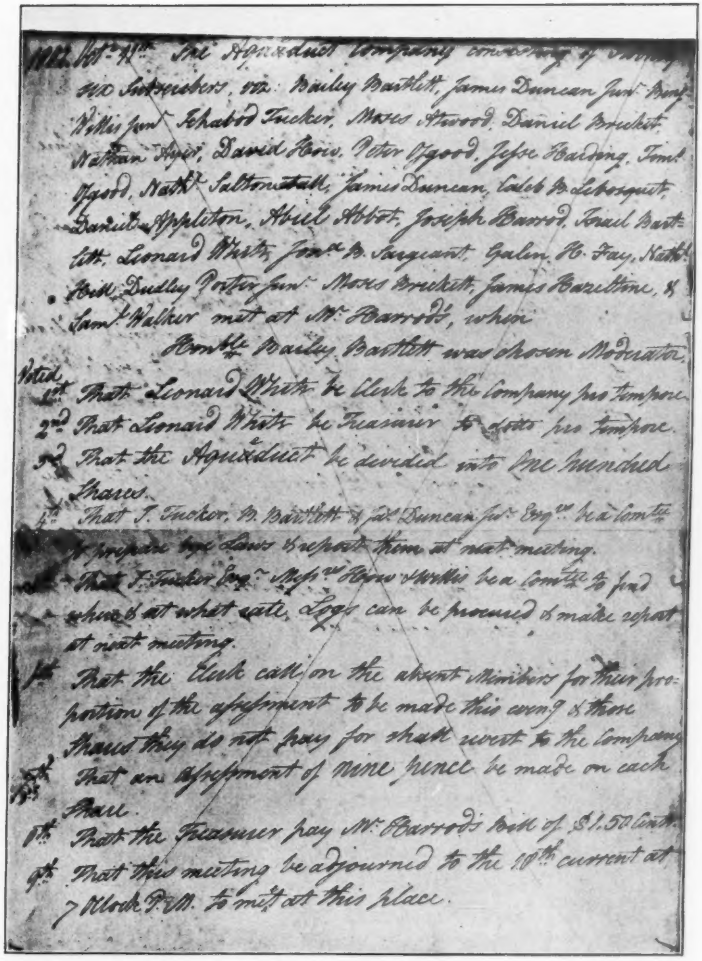
who reported that leave ought to be granted provided that a book for the subscription to the stock was opened to all who chose to take a share; that no one should be allowed to take more than one share until ninety days after the book was opened, at the end of which time the remaining shares might be taken by any of the subscribers; and that the rules of the company be offered to the town for approbation. The following is a copy of the advertisement inviting subscriptions to the stock of the new company.

AQUEDUCT COMPANY.

Notice is hereby given, a subscription
open at the store of Benja. Willis Jun.
for Subscribers to the Aqueduct Company,
which will be kept open for ninety days
agreeable to a vote of the Town, for
any person who may wish to become
a proprietor.
HAVERHILL June 10, 1802.

We might wonder why it was that the first water was taken from Round Pond instead of going to Lake Saltonstall or Plug Pond, which were so much nearer. At that time the outlet of Plug Pond was the mill stream that came down the valley between the old cemetery and the road, entering the Merrimac at the foot of Mill Street, and known as Mill Brook. This brook was about one third of a mile long and had a fall of one hundred and twenty-two feet in that distance, which, with the dam before mentioned, gave ample water power. On this stream was situated the first gristmill of the early settlement. Along the stream at the date of the incorporation of the aqueduct were several manufactories, a tannery, a bark mill, a hat factory, a sawmill, a gristmill, and, at a somewhat later date, a woolen mill; and of course the drawing down of the pond to any great extent would affect the water rights of these mills. In fact, in 1815 a suit was entered against the aqueduct company because they were taking water from Round Pond.

In 1814 Leonard White had conveyed land on the brook and the mill privilege connected with the same to the Haverhill Cotton and Wool Manufactory. A mill was started and cloth manufactured. The next year the company, in the name and with the assent of Leonard White, brought action in which they set forth that by



THE FIRST PAGE OF THE MINUTES OF THE AQUEDUCT COMPANY.

supplying the inhabitants of Haverhill with water from Round Pond the company unlawfully diverted the waters which were a part of Plug Pond and to which the owners of this land and mill privilege were entitled. The manufacturing company was awarded judgment, and from that time until 1849 the aqueduct company used the waters of Round Pond, under an agreement whereby they paid the owners of the land compensation for doing it. Later the company purchased all the land between Plug Pond and the Merrimac River, paying sums ranging from $200 to, in a single instance, $10 000. The Leonard White referred to above was the first treasurer of the aqueduct company, and was placed in the position of bringing suit against his own company on account of having sold the land to the woolen mill.

Having received their charter, the parties interested soon took steps to organize the company, and on October 11, 1802, met at Harrod's Tavern, which stood on the site of our present city hall. I have here the records of that first meeting; this and the records and accounts for many years being in the clear, legible writing of Mr. Leonard White, the clerk, who was, I believe, later the first cashier of the Merrimack National Bank at its incorporation in 1814. (Plate I.)

I ought, as a careful historian, to call your attention to the fact that if they did not at once begin to water the stock, they did at this first meeting mix rum with their water, to the success of the new company, in the good old West India variety, and here is the bill of Landlord Harrod covering the same. (Plate II, Fig. 1.) And I regret to say that this is not all of the sad tale, for as the company got under way their thirst increased in quantity and quality. Let me give you another sample. (Plate II, Fig. 2.)

The managing directors of the company were Hon. Bailey Bartlett, Benjamin Willis, and James Duncan, Jr., and in looking over the records of these early days I have been impressed by the very businesslike way in which all was done. Although the town was small and these men must have seen each other daily, every order to the treasurer for the payment of money is in the writing of the directors; and Mr. Harrod, who was one of the incorporators, never forgot to put in his bill for liquor consumed. When James Duncan went to Boston and brought out the iron for binding the logs, we

find his bill for thirty-five cents, and there is a bill from Bailey Bartlett of thirteen cents for a paper book and other items, concluding with a charge of forty dollars for overseeing the laying of the logs. They all appear to have cheerfully paid out of one pocket assessment after assessment on their stock, and then as cheerfully got the most of it back into the other pocket in the shape of bills and sundry small dividends declared from time to time.

We have heard considerable at some of our meetings about specifications for iron pipe, and you may some of you like to hear the original contract and specification for pipe made in 1803:

Articles of Contract and agreement made this 26th. day of Jan. 1803 Between Bailey Bartlett, Benj. A. Willis and James Duncan Jr. in behalf of Haverhill Aqueduct company on the one part and Enoch Noys of Barr in New Hampshire on the other part witnesseth

The said Enoch Noys for the consideration hereafter expressed does hereby contract and engage to deliver at some landing near Haverhill Bridge on or before the 20th day of May next, eight thousand feet in length of good sound white or yellow pine timber of the following dimentions; no stick to be less than fifteen feet in length; one third of the quantity to measure at the top end nine inches; one third ten inches, and one third twelve inches, the same to be straight and sound and said measure is to include the heart only.

And the said Bartlett, Willis and Duncan in behalf of said proprietors do hereby engage to pay said Noys at the rate of twenty shillings for each and every ton the same shall measure, reconing the same as measured at the top end and free from sap and of the three several dimentions as above stated, the same to be paid on delivery of the whole timber.

BAILEY BARTLETT
BENJ. WILLIS
ENOCH NOYES

Signed in the presence of
ROBERT McGREGOR

CONTRACTS TO BE MADE FOR THE AQUEDUCT COMPANY IN HAVERHILL.

1803
May 3. No. 1 First for Digging the Ditch to lay the Logs from a Stake & Stones near the Pond Brook to a Stake & Stones by Sam Walkers land about 150 Rods — the ditch to be not less than 3½ feet Deep and wide enough to lay the logs, the bottom of the Ditch to be level, sufficient for the logs to lay fair on the same.

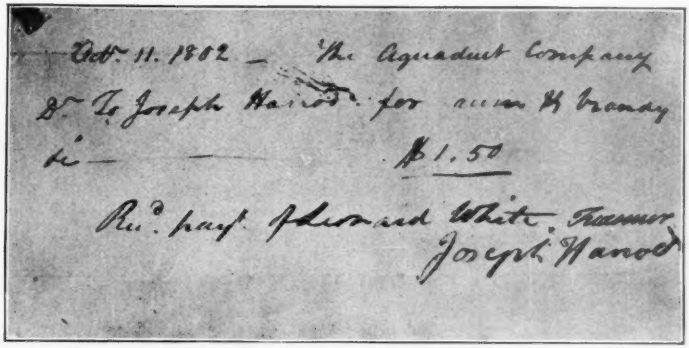


FIG. 1. FIRST BILL PAID BY THE AQUEDUCT COMPANY.

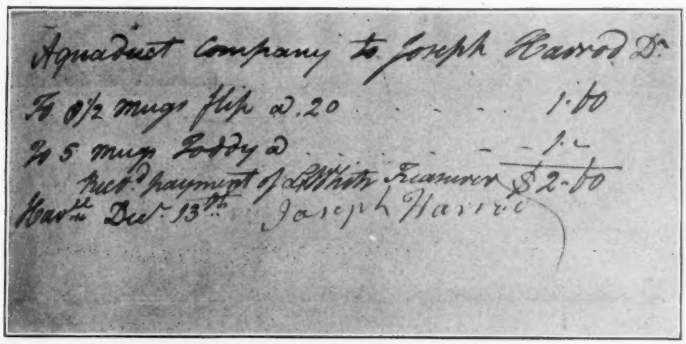


FIG. 2. ANOTHER EARLY BILL.

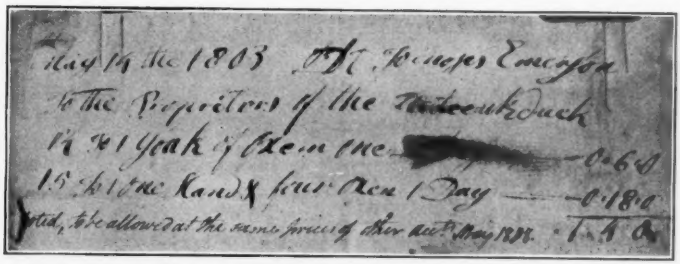


FIG. 3. BILL FOR HAULING LOGS.

No. 2 Contract — beginning at the lower End of N°. 1 — and continue to Caleb Bosquets House opposite the Front Door.

No. 3 From the above mentioned Door to Hav'll Bridge.

N. B. In case, the Contractors in digging any part of the ditch abovementioned, should come across any Rocks of more than ten hundred Weight or Fast ledge of Rocks they shall have liberty to dig round the same, or to remove the rocks at the direction of the Directors, in which case the Directors will pay the extra expense. Where it is necessary to take down any walls in the prosecution of the work, they shall be put up by the directors at the expense of the aqueduct Company.

No. 4 Contract for covering the Logs when laid; the whole dirt taken out, to be thrown upon the Logs as fast as they are laid, and ready for covering. From the Pond to the Bridge the same to be by the Rod.

No. 5 Boring Fixing & laying the logs Fit for Covering, the Proprietors to find the Iron Hoops to put on the ends of the logs. 4000 feet of Logs with a two Inch Augur
4000 feet Do 1½ Inch bore — to be well rimmed out. the whole to be done in a workman like Manner and to the approbation of the directors and to Include the logs to extend from the main logs to the Houses

The contractor evidently had good luck, for here is the bill of Moses Emerson, dated May 14, 1803 (Plate II, Fig. 3), against what he terms the "Accuduck" for the use of oxen in hauling the logs from the landing. But I must stop no longer with these interesting relics of the past.

Returning again to the log aqueduct, let me refer to some of the early trials and tribulations that even to the present day are connected with water-works administration. After the water had been let on, the pressure was so great that the log pipes, unable to stand the strain, burst. This was a grave difficulty, and all the hydraulic skill of the times was brought to bear on the problem. At last the idea was hit upon of making a break in the pipes half way down the hill, by digging a pit, and thus relieving the pressure. This pit was placed nearly opposite the Unitarian Church and remained there for nearly forty years.

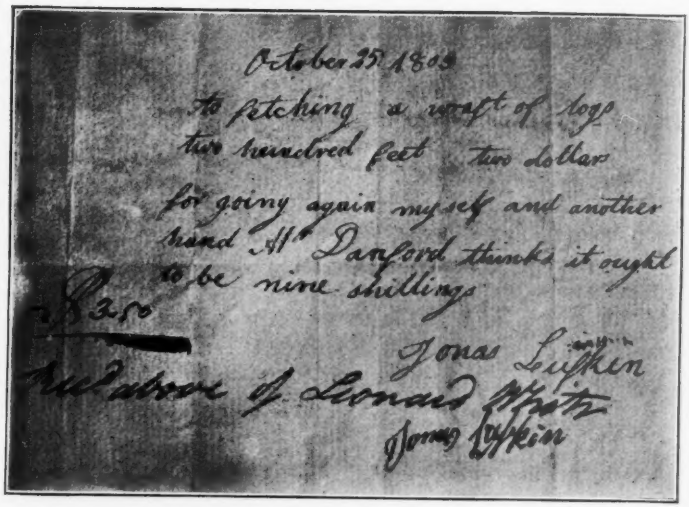
In the early stages of the company no water was carried above

the first story of the houses, and no lead or metal stop cocks were in use. The logs were brought directly into the kitchens and cow yards, and an upright bored log with wooden faucet held the water for use. A curious device was used on Main Street, near the North Church, to elevate the flowing water so as to bring it into the kitchens of the houses. It was found that the water would flow through the logs all right, but it would not stop to be taken on the way; and to remedy this evil, an upright log was interposed and bored double, so that the water was forced to ascend one tube to the top and flow over for its passage down town. This held the water back so that customers on the level street could get a supply. This was considered a great piece of engineering skill, and some elderly citizens might doubtless recall how as boys they jumped on the log and listened to the murmur of the water as it flowed over.

It has been said that various evils result from indulgence in strong drink, and in the case of the aqueduct company it took the form of — betting! The hydraulics of the working plant of the company caused differences of opinion as to pressure, etc., and at last, doubtless after a business meeting held by the open fire at the hospitable Harrod's, the discussion grew heated, there was a division among them, and the following bet was made:

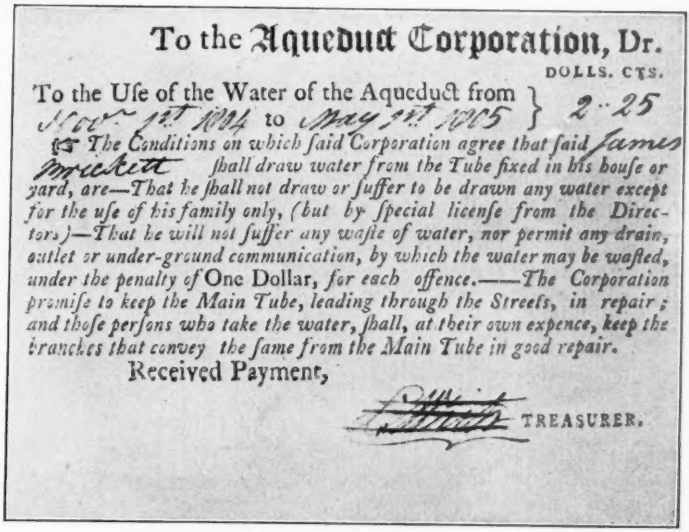
> The bet is in the form following, viz.: a barrel being filled with water and set on the ground a tube of ½ inch bore & 40 feet long inserted into the barrel & made tight, and filled with water and a funnel on the top of the tube filled also with water, the barrel will burst.

Burst.	Will not Burst.
B. Bartlett	J. Duncan
D. How	B. Willis, Jr.
L. White	M. Atwood
O. Tucker	P. Osgood
M. Brickett	B. Willis
C. Kimball	N. Ayer
J. Harrod	D. Brickett
T. Jordan	D. Portor Jun.
T. Brickett	H. West
N. Marsh	
E. Hale	



October 25 1803
To fetching a raft of logs
two hundred feet two dollar
for going again my self and another
hand Mr Danford thinks it ought
to be nine shillings
[redacted]
Jonas Lufkin
Received above of Leonard Smith
Jonas Lufkin

FIG. 1. BILL FOR RAFTING LOGS FOR PIPE.



To the Aqueduct Corporation, Dr.

DOLLS. CTS.

To the Uſe of the Water of the Aqueduct from } 2..25
Nov^r 1st 1804 to May 1st 1805 }

☞ *The Conditions on which ſaid Corporation agree that ſaid James Mickett ſhall draw water from the Tube fixed in his houſe or yard, are—That he ſhall not draw or ſuffer to be drawn any water except for the uſe of his family only, (but by ſpecial licenſe from the Directors)—That he will not ſuffer any waſte of water, nor permit any drain, outlet or under-ground communication, by which the water may be waſted, under the penalty of* One Dollar, *for each offence.——The Corporation promiſe to keep the Main Tube, leading through the Streets, in repair; and thoſe perſons who take the water, ſhall, at their own expence, keep the branches that convey the ſame from the Main Tube in good repair.*

Received Payment,

[redacted] TREASURER.

FIG. 2. AN EARLY BILL FOR WATER RATES.

As the town grew, the two-inch logs were found insufficient to supply water, and about 1830 four-inch logs were substituted, and the aqueduct was extended to some of the streets intersecting with Main Street. The price at first charged was $4.50 for houses and beasts, providing subscription for taking the water was made before the logs were laid, otherwise it was to be $5, and an additional charge was made for each additional post. There appears to have been no printed rate sheet until 1822. In making this the proprietors evidently took as a basis the rules and rates of the Salem and Danvers aqueduct as established in 1797, which I have altered in several places, and marked "adopted by the Haverhill Company." The rules as finally adopted and printed were as follows:

RULES AND REGULATIONS of the
HAVERHILL AQUEDUCT COMPANY, AS AGREED
ON BY THE PROPRIETORS, JUNE 14, 1822.

Article 1. — The Proprietors engage to support the expence of maintaining the main tube from the Pond, and ten feet offset from the same, measuring from the centre of the street; the remainder of the branch and vent-stock shall be made and supported by the person who takes the water, under the care and direction of the Agent of the proprietors, or of one of the directors.

Article 2. — The Annual sum to be paid for the use of the water from said Aqueduct, shall be as follows . . . viz.
For all families less than nine persons in a family, Eight Dollars.
For all private families of nine persons, or more, Nine Dollars.
For a Tavern or public Boarding house, Eleven Dollars.
And if for a House and Stable, Fifteen Dollars.
One half to be paid to the Treasurer in Six months, and the remainder in Twelve months from the time of taking the water.

Article 3. — The Annual sum to be paid by Distilleries, Manufactories, or other persons not included in the above, shall be such a sum, and under such regulations as may be agreed on with the Directors, to be paid in the times above specified.

Article 4. — No person taking the water from said Aqueduct, shall suffer a waste of water, or permit any person other than his own family to take the same.

Article 5. — Every person having a branch shall be subject to have the drawing place therefrom, and everything appertaining thereto, inspected at the direction of the Agent, or one of the Directors, whose duty it shall be to superintend the works generally.

Article 6. — Should there be a deficiency of water, on notice thereof being given to the Agent or one of the Directors, the pay for such time shall cease, if occasioned by a want of water in the main tube; but the proprietors will in no case be responsible for defects in the offsets or ventstocks, arising from frost or other causes.

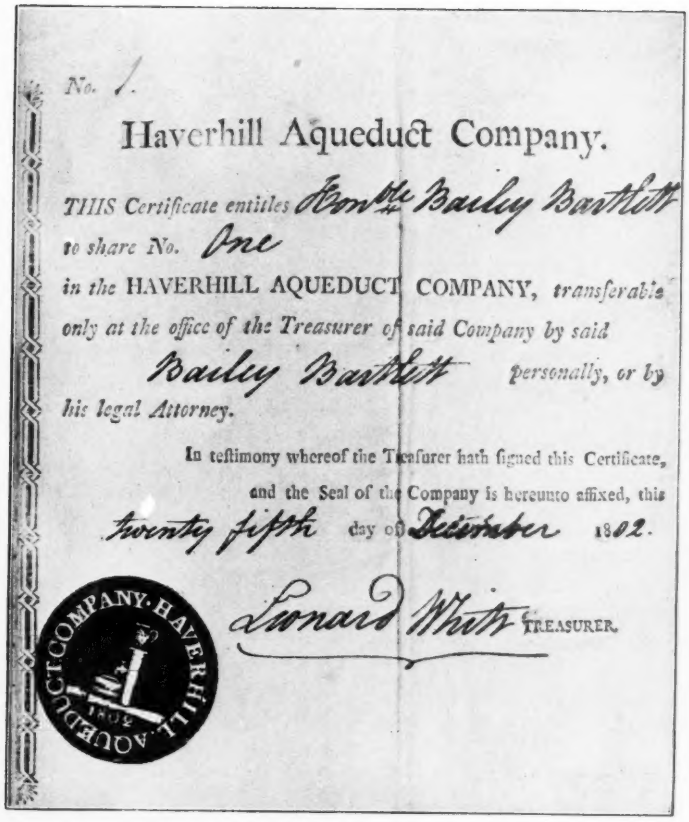
Article 7. — In order to prevent freezing, all persons taking water for family use will have liberty (at their own expence) to take it into their cellars, as well as above stairs.

Article 8. — Each person taking the water from said company, shall be furnished with a printed copy of these rules subscribed by the Clerk, and shall also subscribe a like copy to be kept by the Clerk of said company, stating that they will conform to these regulations and also stating the number of persons in his family and the use he expects to make of the water.

CHARLES WHITE, Clerk to Props.

The prices for water varied somewhat until 1845, when a uniform tariff was made for ordinary family use, and the rates were not materially changed thereafter until the works were taken over by the city.

An old man by the name of Jordan had sole charge of the works, and the boys were in the habit of calling the aqueduct the " River Jordan." He bored the logs, put them down, attached faucets, made repairs, thawed out the stream when it was frozen, made out the bills, and collected the money as well as he could. He was the one who " ran the machine." His services were in constant demand, especially on frosty mornings, and old boys have told the story of being called out in the cold gray of the morning to hunt up " old Jordan " to thaw out the frozen logs. His house was at



No. 1.

Haverhill Aqueduct Company.

THIS Certificate entitles Hon.ble Bailey Bartlett to share No. One in the HAVERHILL AQUEDUCT COMPANY, transferable only at the office of the Treasurer of said Company by said Bailey Bartlett personally, or by his legal Attorney.

In teſtimony whereof the Treaſurer hath ſigned this Certificate, and the Seal of the Company is hereunto affixed, this twenty fifth day of December 1802.

Leonard White TREASURER.

HAVERHILL AQUEDUCT COMPANY 1802

FIRST STOCK CERTIFICATE ISSUED BY HAVERHILL AQUEDUCT COMPANY.

the corner of Main and Pond streets, and an elderly gentleman told me within a year that he well remembered the piles of logs stored by the roadside, and watching the boring process carried on. I have two samples of the log aqueduct (Plate V). This large section is undoubtedly a piece of one of the very early logs laid, as it was dug up at the corner of Main and Water streets. The other section is of a much later vintage, being dug up on Kenoza Avenue. You will note the marks where it was strengthened by hoops of iron.

About 1840 the old aqueduct was found to be inadequate to supply water, and Charles Minot, Esq., a well-known lawyer, took it in hand, raised money, and extended the pipes. The number of shares was one hundred and the par value, I believe, was $25. With the funds obtained he laid some iron pipe and put the works in better repair. After a few years Mr. Minot was called to act as superintendent of the Boston & Maine Railroad and the aqueduct was purchased to a large extent by Hazen Haseltine, an active business man of the times. His business career was, however, terminated by a failure, and among his assets was a majority of the stock of the company, which passed into the hands of his brother, Ward B. Haseltine, of Philadelphia, who took it, much against his inclination, as security for money loaned to his brother.

Soon after 1845 it was found that more water was needed, and Plug Pond was tapped. Quite a controversy took place at this time over the so-called encroachment of a soulless corporation in planning to take water from this pond, and so destroy forever the beauty and utility of the old mill brook. The culminating point was perhaps reached in the following communication, published in the *Tri-Weekly* by one who signed himself " Mill Street ":

" More beautiful to my youthful eyes were the buttercups and thistles which grew on the borders of this much-talked-of brook than the rarest exotics in the parterres of the wealthy and great. The fairy-like music of its crystal waters, as they roared and rippled and seethed and surged and tumbled over its stony bed, was ever suggestive of elves and water-nymphs.

' I envied the brook as it glided along,
Thro' its beautiful banks in a trance of song.'

But there is one point your correspondent has failed to notice,

which would, 'I apprehend,' be more regretted by lovers of art than words could express. I refer to the sweet and pathetic music of the frogs. Have you ever, Messrs. Editors, on a calm, moonlight midsummer's eve, seated yourself on the grassy bank of the upper Mill Pond and drank in the beauty and inspiration of the scene? the majestic rock-ribbed hills in the distance, the stately poplars, the regal sycamores, and the graceful elm reflecting every limb, and twig, and leaf, in the glassy mirror below; the whole scene, so tranquil and soothing, undisturbed by any earth-born sound, save the dulcet melodies of the frogs. The deep diapason of the masculines, the soft, tender responses of the lady frogs, the sweet baby trills of the pollywogs, and the blending of the three in one harmonious whole, produce such a 'concord of sweet sounds' as to make one feel in his heart of hearts the sentiments of the immortal poet, 'linked sweetness long drawn out.'

"I, in company with appreciative friends, have often listened in charmed ecstacy, and the memory of such evenings is 'a joy forever.' And are we, and our children, and our children's children, to be deprived of this exquisite source of enjoyment, so refining and exalting in its nature, for the accommodation of a 'few individuals' who, under the pretence of 'supplying the town with pure water,' are committing acts of vandalism on Mill Street that *no* necessity ought to justify?

"MILL STREET."

Again, in 1867, the two sources of supply proved inadequate, and the owners went to the legislature for permission to draw water from Kenoza Lake. An act was passed, with certain restrictions:

1. Private property was safeguarded by preventing the raising of the ponds *above* high-water mark or lowering them below low-water mark.

2. The water of none of the ponds could be used to drive machinery.

3. A plan was provided by which the city could take over the works.

In 1848, at the town meeting, a proposition was made for the town to pay the difference between a 5-inch and 8-inch iron pipe from Round Pond to the top of the hill on Main Street, the Aqueduct Company being about to replace the old logs with a 5-inch pipe of iron. A committee to whom it was referred reported in favor of a 6-inch pipe, which was laid, the town paying the difference in cost. Soon after this Mr. James H. Carleton obtained

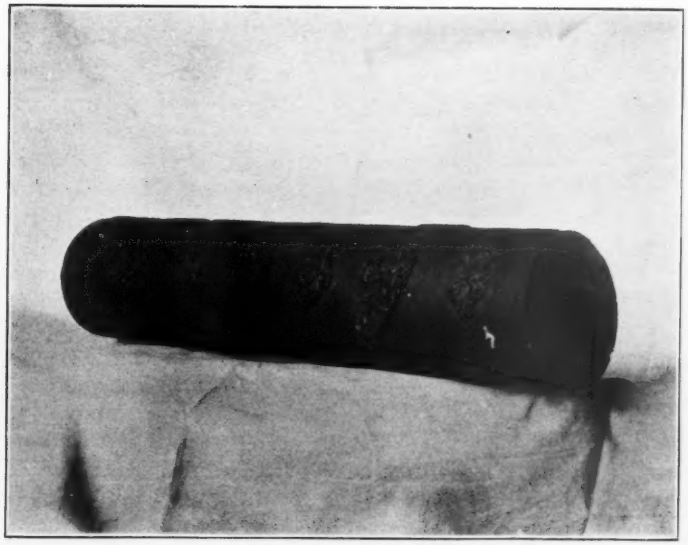


FIG. 1. PIECE OF LOG PIPE.

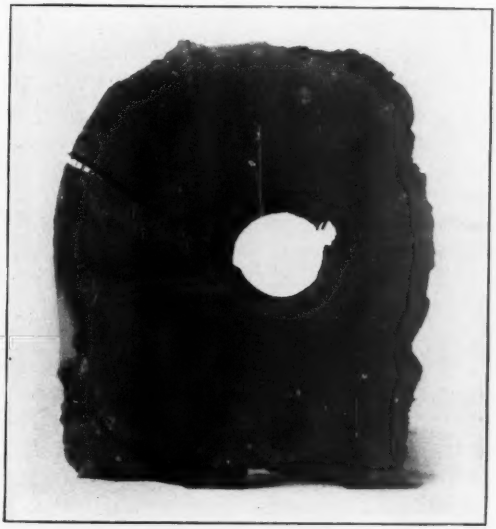


FIG. 2. SECTION OF LOG PIPE.

control of a number of shares held by various local people. For more than forty years the stock was owned by the two previously-named gentlemen, the rest being divided up among five prominent citizens. Mr. Carleton was for many years treasurer and superintendent, being succeeded later as superintendent by Mr. Charles W. Morse, who continued until the city took possession in 1891.

In 1871 a small pump was erected at Kenoza Lake and water was pumped into Round Pond, the system still being gravity. In 1879 the growth of the city had extended greatly and buildings were being erected on the high lands of the city, and the company then added what is now known as the old pumping station, erected a standpipe on Kenoza Avenue, and began to supplement the gravity system by a high-service system. At the same time there was in the western part of the city a reservoir on Silver Hill, or Mt. Washington. This was supplied from springs and was the property of the Silver Hill Aqueduct Company, and was used for the purpose of supplying a little settlement of houses in that vicinity. The Haverhill Aqueduct Company at this same date acquired by purchase and deed this property.

In 1882 it became apparent that there was a permanence in the growth of the city which would require a greater supply than they were then enjoying, and the same year they went up to Crystal Lake and acquired the mill sites on the stream flowing from the lake. In 1884 the legislature granted them the right to use the water of Crystal Lake as a source of supply, and the company immediately laid its line of 16-inch cement pipe from Crystal Lake into the city. In 1889 the growth of the city on the high lands of Mt. Washington had continued and it was again necessary that the high-service system should be supplemented. Another standpipe was erected on a tract of land acquired for the purpose on Grove Street.

In 1884, owing to the dissatisfaction of some of the large water takers with rates, an agitation was made looking to the purchase of the plant by the city, under the Act of 1867; hearings were held by a committee of the city government, but nothing was at this time done. In 1890, however, another committee was appointed, with an appropriation of $500, to investigate and report on the advisability of acquiring the property and franchises of the Aqueduct

Company. After an exhaustive hearing, the formal order of taking was passed by both branches of the city government, and the order was approved by Mayor Burnham July 10, 1891. By this order the mayor was directed to apply to the Supreme Judicial Court for the appointment of three commissionars who were to determine the price of the franchise, rights, and property of the company. The Court appointed Hon. George O. Shattuck, John E. Sandford, and Weston Lewis as commissioners. They held their opening session May 14, 1892, and on the 17th day of October, 1892, the commissioners reported that the price to be paid by the city was $637 500, with interest from the 6th day of July, 1891; the city was also to pay the fees of the commissioners, which were fixed at $7 655.

The Aqueduct Company was represented by Hon. William Gaston, E. T. Burley, Esq., Boyd B. Jones, Esq., and Frederick E. Snow, Esq.

The counsel for the city were Hon. George D. Robinson, Hon. William H. Moody, and Edward B. George, Esq.

The total cost to the city of the hearings, including experts and counsel fees, was about $22 000.

The authority under which the works were taken by the city and have since been conducted was an act of the legislature, passed in 1891, and two supplementary acts passed in 1892 and 1896. These acts were drawn by Hon. William H. Moody, now one of the justices of the United States Supreme Court, who at that time was chief counsel for the city, and on the formal taking of the works was appointed one of the water commissioners. The original act was different from other acts regarding water supply in several particulars. Mr. Moody writes me that "the main purpose which I sought to accomplish, carrying out in this respect the wishes of the mayor and city council then in office, was to separate completely the water department from all other affairs of the city. It was hoped thus that the department would be managed upon strictly business principles without regard to politics. To that end it was provided that the water commissioners should be appointed for a term of five years, that only one should be appointed each year, and that the city be left to pay for the water which it used like any other consumer. The power of management of the

department was vested exclusively in the commissioners, subject to removal by the city council for cause." Mr. Moody further writes that " in the Act of 1892, which referred to the taking of lands for the protection of the water supply, I put into it the provision that any land taken for the protection of the water supply might be managed, improved, and controlled by the water commissioners in such manner as they should deem for the best interests of said city. The purpose of this provision was to enable the land thus taken to be used for the purpose of a public park, as it has since been. I hoped for good results, but I didn't realize that the result would be a most beautiful park in which all our people may justly delight."

Under this act the water board has taken 623 acres of land, at a cost of $157 432, the larger portion of this being about the storage basin and Kenoza Lake. A portion of this is placed under the control of the park department at the discretion of the water board.

For five years the city paid for the water used in all public buildings and drinking fountains. Then came the same trouble that so many water works have had to meet, — a city council short of money, — and the question was raised why, as the city owned the works, any rates should be paid. The matter dragged along for several years, but no adjustment was ever made, and the city has since then not paid a penny for water. In our case it has seemed particularly unjust, since not a dollar has ever been paid by the city towards buying the plant, operating it, or toward the sinking fund.. We charge the owners the entire cost of putting in the service, and the city pays all bills of this kind for the different departments of the city.

Early in 1882 Haverhill was visited by a disastrous fire that reduced almost the entire " shoe district " to ruins. The next year the city council appointed a committee on water supply, authorized " to cause to be laid by contract or otherwise cast-iron pipe 12-inch in diameter, to be connected at the North Church with the high-service pipe of the Haverhill Aqueduct Company." This pipe was to be used exclusively for fire service, and was laid through the main streets of the city, taking in the retail section and that portion occupied by shoe factories. An appropriation of

$30 000 was made covering the cost, and the work was done under the direction of the committee. As the manufacturing district has expanded, calls have been made for extension of the high service in various parts of the city, to be used exclusively for fire protection, and appropriations have been made by the city council, the water department doing the work.

The hydrants are all under the control of, and are furnished by, the fire department, but are set by our department and the expense paid by the city.

The water commissioners have the right to fix the water rates; the income, after deducting all expenses and charges of distribution, is applied, first, to the payment of the interest on the bonds; second, to the payment of the sinking fund requirements (two per cent. of the total amount of the bonds); third, to the payment of all current expenses; fourth, the balance, if any, may be applied to the sinking funds in the discretion of the commissioners. We are also allowed to expend not exceeding twenty thousand dollars in any one year for the purpose of new construction. In case the surplus should not equal the two per cent. required for the provision of the sinking fund, the city must raise such sum by general taxation.

Our department receives all money from rates, etc., and pays its own bills, the only connection with the city being the appointment of a commissioner each year by the mayor, the auditing of the books of the department by the city auditor, and the payments for interest and sinking fund, which are made to the city treasurer. The result aimed at has been achieved, the department having been so far kept entirely out of politics.

None of the commissioners, with the exception of the chairman, receives pay, and up to the present the members of the board have all been leading citizens who have freely given of their time, and have been reappointed as long as they desired to remain upon the board.

The improvement and development of the system since its acquisition by the city have been on the lines laid down by the consulting engineer, the late Freeman C. Coffin, who in January, 1895, submitted an exhaustive report on the needs of the plant, and the sources of additional supply; and the result is a system

fully equipped and capable of supplying an abundance of pure water, at a cost to the consumer comparing favorably with other cities of the country. At the present time, a large section of the city is supplied by gravity from Crystal Lake, Round Pond, and Lake Saltonstall. Kenoza Lake supplies those portions of the city that are dependent on high service, and also furnishes water for the fire service, the water being pumped to a reservoir of 9 000 000 gallons capacity, built in 1898. As an auxiliary supply we have Millvale storage basin, which was built in 1894–5 by damming East Meadow River, and which has a capacity of 118 000 000 gallons. A Worthington engine with a capacity of 8 000 000 gallons per day is installed at Millvale, and the water is pumped through a 24-inch pipe into Kenoza Lake, a distance of one mile, as required to keep that lake at a proper height. A 16-inch pipe connects Kenoza Lake and Round Pond. At the new Kenoza station, erected in 1900, are two pumps, one made by the Barr Company, of Philadelphia, with a capacity of 6 000 000 gallons; another of like capacity made by the Platt Iron Works Company, of Dayton, Ohio.

In 1896 the town of Bradford, situated on the south bank of the Merrimac River, was annexed to Haverhill, and the Water Board took in charge the water system of that town, which had been installed by Messrs. Goodhue & Birnie, of Springfield, as a private enterprise, and later taken by the town. The water for this portion of the city is furnished from Johnson's Pond, with an area of twenty-two acres, and is all high-service, pumped to a reservoir of 1 000 000 gallons capacity by a two-million-gallon Deane pump. The water board is about to install a second pump at the plant, and eventually will probably lay a pipe across the river, which would be of use to either section in case of emergency.

We supply an estimated population of 37 600, our consumption being 134 gallons per day to each consumer. This high consumption is due to the fact that outside of the business portion of the city the use of meters has been optional, and at the present time we have in use only eight hundred meters. We have eighty-four miles of main pipe, cement lined and cast iron, ranging in size from two to twenty-four inch. The pressure on the low service ranges

from thirty-five to forty pounds, while the high service is from eighty to one hundred and twenty. The original cost of the works in 1891 was $720 504.17. The cost of the works December 1, 1907, which, of course, includes all the improvements above mentioned and the land purchased, was $1 466 594.51, while the net debt at that same date was $646 491.

And in addition, what is after all of the most importance to the water takers of the city, is the fact that since 1892 the rates have been year by year decreased. After several reductions in the tariff of rates, the commissioners adopted the policy of a discount of 5 per cent. for prompt payment of bills, and this has been increased to 10, 15, 20, and 25 per cent.

Like many another of the old landmarks, the log aqueduct long since passed away, and except perhaps as a matter of history, is no longer interesting. But the main fact remains, that we have to-day an institution that has survived since 1802 and has developed to its present condition. Started by some of the leading men of the time, identified with the growth of the old town, it certainly was not altogether for what there was in it. For years its earnings were small and less than the expenses, and even after its reorganization, for a long period no dividends were paid, and assessments on the stock were made. And not only that, but the task was a thankless one. The community viewed the venture as chimerical, and the individuals engaged in it as foolhardy in the extreme. The town scoffed at the idea, and the multitude believed that there was not then nor ever would be any use for such a contrivance as an aqueduct.

Who can say to-day how much the existence of the facilities for water afforded through the past history of the town and city, and due largely to the enterprise of these townsmen, has contributed to its progress and present prosperity?

DISCUSSION.

MR. M. N. BAKER. Mr. President, I think we are all agreed that this is a unique contribution to the history of American water works, and that the author of the paper is to be thanked for having taken so much pains to bring together such a large amount of valuable historical matter. It would be a very fine thing if others

in position to do so would follow his example and put on record the history, in so far as it has not yet been done, of at least those water works that were built up to the early part of the nineteenth century. The number of works, as has been stated in the paper, in operation up to the close of 1800 is small. Even well into the nineteenth century, there were only thirty-two works. I hope that it will be feasible to reproduce in the JOURNAL some of these very interesting historical documents which Mr. Sawyer has shown us. I am sure they would be of great interest to all the members of the Association, and of value to others outside of the Association who may wish to refer to the JOURNAL in the years to come for just such matter as this. Those of us who have attempted to make similar investigations know how difficult it is to bring together material of this sort, and I think it is very rare indeed to find such complete records, covering a period so long past.

BULLETIN OF THE HOQUIAM WATER COMPANY, HOQUIAM, WASH.*

BY HARRY C. HEERMANS, PRESIDENT.

CHEAP TRANSPORTATION AND DELIVERY OF PUBLIC WATER SUPPLY.

Examine the tables in this bulletin. They will agreeably surprise you. Please remember in paying your water bill that you pay for the collection, pumping, and delivery of an adequate water supply, *when* you want it, *where* you want it, and in quantity to supply your requirements. No worry. Your rate is based on the quantity required for the uses you specify in your application to the water company. You do not pay for wastage and you are, therefore, requested to treat the company fairly and prevent waste. That is the only square deal. Think of the luxury and cheapness of a public water supply. You make no investment for wells, or cisterns, or storage tanks; no labor at home pumping water or cleaning cisterns, wells, or tanks, and no payment of constant repairs to the same. The public supply furnishes your home with hot or cold water everywhere if you want it and is the cheapest commodity you buy.

Think of these facts and *smile* when you pay your bill to the water company.

COST OF WATER, DELIVERED BY WEIGHT, ACCORDING TO VARIOUS RATES, THROUGH WATER-WORKS SYSTEMS.

Attention is called to the fact that the delivery of water by weight, through public water supply systems, as a commodity, is the cheapest in the known world, in comparison with other transportation; for instance, the switching of a car containing fifteen tons of freight, switched within the city limits by any railroad company, would not be less than $2.00, or 12⅔ cts. per ton.

Last summer the Hoquiam Water Company paid for the switch-

*This bulletin is reproduced for the benefit of water-works managers generally.—EDITOR.

ing and transportation of carloads of water pipe, a distance of not over two or three miles, the sum of $15.75 per car, or .877 cts. per ton (wire banded wood pipe).

We are now collecting the Hoquiam water supply at the average distance of five miles from town, pumping and delivering the same to consumers in their homes at any elevation required, not exceeding 200 feet above sea level, at the rates per ton as shown in the following table:

Prices per 1 000 gallons delivered through water-works systems.....	$0.08	.15	.20	.30	.45	.50
Prices of water per ton, delivered by various water companies.....	$0.019	.036	.048	.072	.107	.119

One thousand gallons of water weighs 4.175 tons.
One gallon of water weighs 8.35 pounds.
One cubic foot of water weighs 62.42 pounds. — (Trautwine.)
One cubic foot of water contains 7½ gallons.

THE REASON WHY WATER TAKERS SHOULD PREVENT LEAKS IN PLUMBING FIXTURES.

[Data taken from book on hydraulics, by Geo. A. Ellis, C. E.]

Amount of water, in gallons, that will pass through pipes or jets of various sizes in one hour under different pressures of the Hoquiam Water Company:

Size of Openings.	85 Pounds Pressure.	90 Pounds Pressure.	95 Pounds Pressure.	100 Pounds Pressure.
1-16 inch.....	64.2	66	67.8	69.6
1-8 „	258.6	265.8	273	280.2
3-16 „	577.2	593.4	612	624
1-4 „	1 032	1 062	1 090	1 122
3-8 „	2 310	2 376	2 442	2 502
1-2 „	4 128	4 248	4 368	4 476
5-8 „	6 420	6 600	6 780	6 960
3-4 „	9 300	9 600	9 880	10 080
7-8 „	12 600	13 020	13 380	13 680
1 „	16 500	16 980	17 460	17 940

The following acts are prohibited:

1. Allowing water to run to waste, or to run to prevent freezing.
2. Having leaky water fixtures on the premises.
3. Using a hose without a nozzle.

4. Using a nozzle with an orifice of more than one fourth of an inch.

5. Using water through a hose unless hose is held in hand.

6. Using water through a hose between the hours of 9.00 A. M. and 5.00 P. M.

7. Using an automatic sprinkler at any time unless such sprinkler is connected on a meter.

8. Using water through a hose during the progress of a fire in the city, except upon the fire.

9. Using water through any plumbing fixtures without first applying for and obtaining permission for such use.

10. Allowing water to be taken from premises by persons having no right to its use.

11. Willful waste of water in any way.

PRIVATE FIRE PROTECTION AND INSURANCE RULES.

BY GORHAM DANA, MANAGER, UNDERWRITERS' BUREAU OF NEW ENGLAND, BOSTON, MASS.

[*Read November 11, 1908.*]

In the work of laying out private fire protection for manufacturing and mercantile buildings, the insurance engineer frequently meets with opposition from the water departments. From my experience in this work, covering nearly fifteen years, I think it safe to assume that most of the water-works superintendents look upon an insurance engineer as an unreasonable fellow, who has all sorts of ridiculous rules, and whose main object is to get all he can out of the water department for himself or his client without giving anything in return.

It occurred to me that a frank explanation of the scope of our work and the reasons for our requests might put them in a better light before you and clear up some of the past differences in opinion.

As a matter of fact, the insurance engineer is not as unreasonable as he may appear. What he asks is from no selfish motive, for improved protection means lower insurance rates and less income for the insurance companies. The average local insurance agent prefers not to see sprinklers installed in the buildings he insures, for it means less premium to him.

What the insurance engineer does for one plant or individual is of benefit to the whole community, for it means lessening the chance of a serious fire, and, therefore, lower insurance rates for all.

The rules that he works under are no arbitrary rulings made by himself or by his manager, but they are National Standard rules drawn up by committees of the National Fire Protection Association. These committees are composed of men from all over the country and represent the experience and best thought of the brightest men in the business.

First of all, I should like to touch on the need of private fire protection, more especially automatic sprinklers, as a means of

reducing the annual fire loss of the country. That there is a need of reducing the fire waste must be apparent to any one who reads the ever-increasing list of fires in the daily papers. The total loss for the last thirty-three years has been four and one-half billion dollars. The average loss for the last few years has been almost two hundred and fifty million dollars. In other words, this loss is going on day and night at an average rate of $500 per minute. This is a direct and real loss to the community, the insurance only distributing the loss amongst many, and not really paying it. To this should be added the indirect loss of some $350 000 000 a year, due to the cost of maintaining fire departments, insurance companies, protective departments, fire-service mains, etc., so that the total fire tax to the country is something like $600 000 000 per year.

But the most discouraging feature of the situation is the fact that this loss is increasing each year by leaps and bounds. In 1875 the loss was only $78 000 000; in 1885 it was $102 000 000; in 1895 it was $142 000 000; in 1906 (the year of the San Francisco conflagration) it was $500 000 000. The loss for August, 1908, is estimated at $23 000 000, or $3 000 000 more than for August, 1907; and for September, $22,000 000, or $9 000 000 more than last year. That this country is far ahead of any other country in fire waste is shown by the fact that the loss per capita is $2.47, while in Germany it is 49 cents, in Italy it is 12 cents, and the average for European countries is 33 cents.

With these astonishing figures staring us in the face, is it not the duty of every one, water-works man, insurance man and all, — to do all in his power to reduce this ever-growing tax?

A large part of this loss occurs in our cities. American cities are growing at a tremendous rate, especially vertically, and our fire-fighting facilities are not keeping pace with the growth. This was well illustrated in the Parker Building fire in New York last winter. Here was a modern twelve-story building of so-called fireproof construction, but used for printing and similar purposes, and containing a large amount of combustible material. To be sure, it had the serious defect of large unprotected stair and elevator openings, but this is a defect that is very common in modern buildings. Fire started and gained some headway before being discovered. The

fire department responded promptly, but was utterly helpless above the eighth story and the fire on the upper floors practically burned itself out.

With this condition confronting us, what are we to expect in a twenty, thirty, or forty-two story building? So long as they are used for offices only, they are comparatively safe, but when filled with combustible material they can no longer be considered fireproof, even though the structures themselves are properly built.

If a conflagration should sweep lower New York, the loss would be in the billions, and probably every insurance company in the country would be put out of business. A panic would result such as the country has never seen.

What is the remedy for this state of affairs? Surely, a fire department now helpless above the eighth story cannot, for many years, at least, be developed so as to be effective at elevations of twenty and thirty stories. The remedy to my mind is the automatic sprinkler.

AUTOMATIC SPRINKLERS.

Sprinklers came into general use about twenty-five years ago, or in the early eighties. Since then they have been steadily improved, until now they have reached such a state of perfection that but little further improvement can be looked for. It is estimated that about 25 000 000 sprinklers have been installed in this country, representing an investment of almost $100 000 000.

Briefly stated, automatic sprinklers are small valves held closed by soft solder, melting at about 160 degrees. When opened, they distribute water by means of deflectors. They are placed throughout a building, 6 to 12 feet apart, and attached to pipes containing water under pressure. In unheated buildings, they are placed on the so-called dry system, a dry valve being introduced to hold back the water until a sprinkler head opens.

For twelve years the National Fire Protection Association has been collecting statistics on fires occurring in buildings equipped with automatic sprinklers. Six thousand and forty fires have been tabulated, and in 93.77 per cent. of these the sprinklers extinguished the fire or held it in check. In the other 6 per cent. they failed, but there was usually some good cause, such as closed

valves, empty tanks, etc. In 65 per cent. of the fires, 5 sprinklers or less opened; in 78 per cent., 10 sprinklers or less opened; in 91 per cent., 35 sprinklers or less opened.

Under normal conditions, sprinklers put out a fire with much less water than would be used by hose streams, and it would seem that for this reason alone water departments should welcome the introduction of sprinklers and do all they can to assist the insurance engineer in laying out a proper equipment.

RULES.

A few words about the rules for installing sprinklers may be of interest to some of you. Sprinkler systems to warrant the lowest insurance rate should have two independent sources of supply, so that if anything happens to one there will still be something to fall back upon. The ordinary supplies used are water-works connections, gravity tanks, pressure tanks, and various kind of pumps. Where pressure and volume are adequate, water-works systems are always considered the most desirable supplies. In fact, in large cities, where the public water supply is first-class, a proper sized connection from such a system is usually considered as good as a tank and pump supply in the country. There should be a pressure of at least twenty pounds on the highest sprinklers to give good protection. The size of main connections and risers is figured large enough to supply the sprinklers on one floor only, the theory of sprinkler protection being that they will control the fire on the floor where it originates. To this end great care is taken to enclose all floor openings, such as elevators and stairs, so that fire cannot readily spread from floor to floor.

The pipes on each floor are graded according to the number of heads supplied by each. The rules for these sizes have been evolved during the last twenty-five years from actual experience and tests. They were changed in 1896 and again in 1905, the sizes being enlarged both times, but the rules as they stand to-day will probably not need any further change of any importance, at least for many years. At present, a 4-inch pipe can feed 80 heads; a 5-inch pipe, 80 to 140; and a 6-inch pipe, 140 to 200 on a floor. Two hundred is as many heads as are often found on one floor between fire walls, and where this number is exceeded, two or more connec-

tions are generally called for. The distance apart that heads are located varies greatly with the construction, but one head to 80 square feet is a rough average.

SIZE OF CONNECTION.

Some water departments object to allowing the proper size connection where the street main is small. This seems to me unwise, for in case of fire, water must be used, and sprinklers will put out the fire with less water than hose streams. If the connection is not large enough, the sprinklers may fail to do what is expected of them and hose streams will then have to be used in addition. Therefore, it appears to be economy for the water department to allow the proper size of connection, no matter what is the size of main.

In some cases a ruling has been made that no connection over four inches in size can be made, although more than one such connection can be had where necessary. This seems to me to be an unnecessary hardship on the taxpayer. In the first place, it generally introduces another gate and check valve, which adds to the expense as well as introducing another chance for trouble, due to valves being closed by mistake. It also means more friction loss.

The only reason I have heard for such a rule is that there is less chance of waste in case of a break. I fail to see why this is so, for if two 4-inch connections entered a building and were brought together to feed one 6-inch riser, a break in this riser would be fed by two 4-inch, pipes, which have a capacity of practically the same as one 6-inch, and in case of a break in the 4-inch, the water would come from each direction and would again be about the equivalent of one 6-inch. As a matter of fact, the chance of breakage in one of these large pipes is extremely small, and it would seem that the benefit from a good sprinkler system would more than offset any possible danger of wasting water at a time when it was needed elsewhere.

Another feature to be considered is the additional cost in case sprinkler supervisory apparatus is installed.

SPRINKLER SUPERVISORY APPARATUS.

Sprinkler supervisory apparatus has only been on the market about two years, but many equipments have been installed in

the larger cities, like Chicage, New York, and Boston. It has already proved its worth and undoubtedly has an important future. Briefly stated, the idea is to affix electrical contacts to all gate valves and other parts of sprinkler systems, in order to give an alarm in case any device is put out of order. Thus, the attachment on a gate valve (Fig. 1) gives an alarm in case the valve is

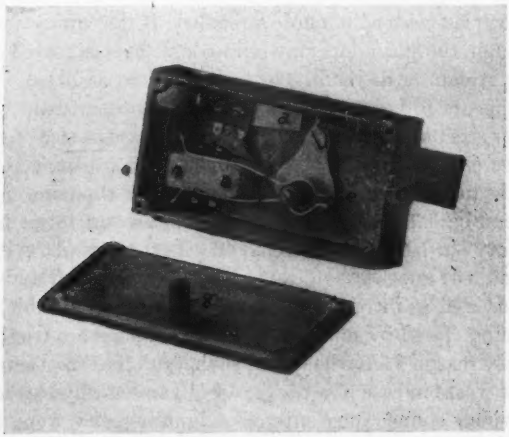


FIG. 1. A. D. T. CO. GATE VALVE ATTACHMENT.

c = case; *d* = case contact; *e* = rubber roller; *ff* = Germah silver springs; *g* = post for closing case contact.

This is designed to attach to a gate valve so as to give an alarm as soon as any one starts to close the valve.

turned more than a fraction of a turn from the position of wide open. The attachment on a gravity tank gives an alarm in case the water level drops below a pre-determined point or in case the temperature gets too near freezing (Fig. 2). The attachment on a pressure tank gives an alarm in case the pressure or water level drop too low. The attachments are so made that they cannot be tampered with and the wiring is on a closed circuit and enclosed in conduit. The wires run to a central station where there are men on duty at all times. In case an alarm comes in, a runner is sent

to see what the trouble is and to remain until it is remedied, when necessary.

With such an equipment, it is almost impossible for a sprinkler system to become crippled in any way, without the trouble being discovered and remedied at once. The chance of sprinkler failures should thus be reduced to almost nothing.

Now each contact, that is, the attachment to gate valve, tank, etc., costs from $25 to $40 a year, and any extra valves required by water departments become a serious question financially. Furthermore, on account of the large number of sprinkler valves that are left closed accidentally where there are no such attachments, the underwriters prefer that as few as possible be installed.

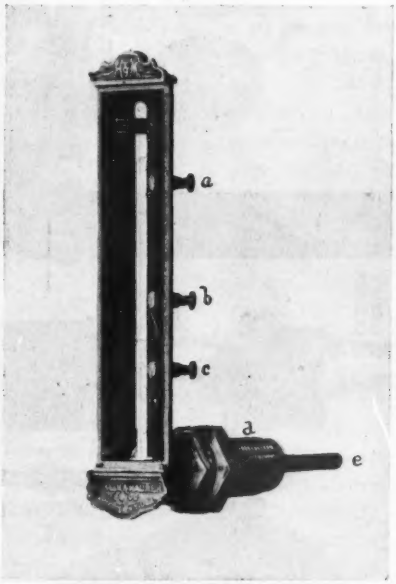


FIG. 2. A. D. T. TEMPERATURE DEVICE.

a = high-temperature contact binding post; *b* = low-temperature binding post; *c* = constant binding post.

This is designed to attach to a gravity tank to give an alarm in case pressure nears boiling point or freezing point.

METERS.

A few water departments in New England are requiring meters in private fire pipes. The underwriters are opposed to this practice on account of the numerous complications it introduces, principally friction loss, chance of clogging, and a considerable extra expense. It is true that the so-called detector meters have overcome the trouble of complications to a large extent, but they are expensive, especially in the larger sizes.

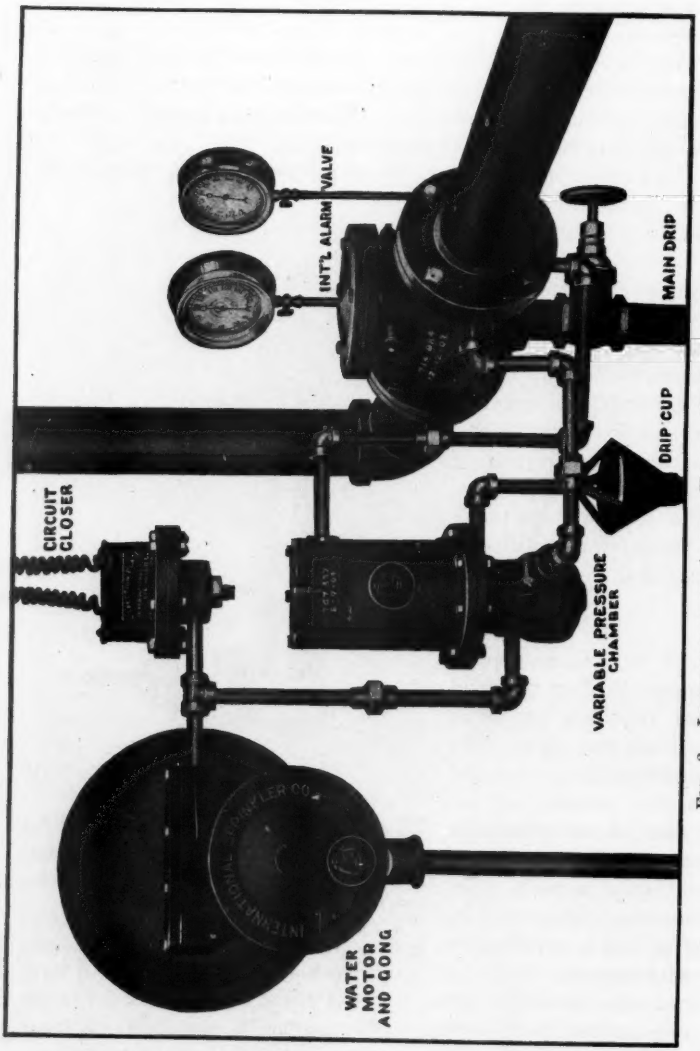


FIG. 3. INTERNATIONAL ALARM VALVE (GENERAL VIEW).

I realize that water is sometimes stolen from sprinkler systems, and that it is the duty of the water department to put a stop to it, but I believe there are other methods of accomplishing this result which are better from a fire protection standpoint.

In the first place, the insurance rules do not allow sprinkler pipes to be used for any other purpose. All water departments should have a similar rule and should enforce it rigidly. In addition, they may seal all drip valves and private hydrants and require that they be notified if a seal has to be broken for any reason. This is done in some cities, and, so far as I know, has successfully prevented any serious trouble.

Few people will steal water willfully. The trouble is generally caused by some engineer or mechanic who taps a fire pipe thoughtlessly, without realizing what he is doing. A pipe cannot be readily tapped without shutting off the water, and this would be brought to the attention of the department by the breaking of seals.

ALARM VALVES.

Nearly all modern sprinkler systems contain alarm valves. These constitute one of the best safeguards against taking water from sprinkler pipes that there is. There are at present two approved alarm valves on the market, the Variable Pressure or English Alarm Valve, made by the General Fire Extinguisher Company, and the International, made by the International Sprinkler Company. The principle in each is similar, namely, a check valve that when on its seat closes a groove or pipe outlet, and when off its seat allows water to flow into the groove or pipe. This water is used to give an alarm by operating a rotary or water motor gong, or by pushing up a diaphragm which gives an electric alarm. Alarm valves have been developed so that now they are very reliable, and furthermore, unlike the older types, they seldom give false alarms. The "International" and "Grinnell" alarm valves are shown in Figs. 3, 4, 5, and 6.

Now an alarm valve placed in a sprinkler pipe is, to my mind, just as good as a meter. No water can pass through the pipe without giving an alarm, provided the alarms are in order. The insurance inspectors go through the plant several times a year

FIG. 4. INTERNATIONAL ALARM VALVE (SECTIONAL VIEW).

The swing check valve 3 tightly closes the outlet of pipe *C* when on its seat. When the check opens, water flows through pipe *C* to variable pressure chamber, hence to electric circuit closer and water motor.

to see that these are kept in order. In cities where there is sprinkler supervisory, such devices can be supervised from a central station, in which case a trouble signal is received if any part of the system gets out of order. If further proof is needed, small-sized meters ($\frac{1}{2}$ or $\frac{3}{4}$ in.) can be placed in the pipe that runs to the alarm connection. In this case, no water can be drawn through the sprinkler pipe without registering on this meter. This does not give the actual amount passing through the system, but the proportion could be roughly figured. In case there is a rule forbidding the use of any water, the amount is not important, for the rule is broken and the person who does it can be punished.

Still another method of checking up the flow of water in a sprinkler system is to place a recording pressure gage on the pipe from the alarm valve. Ordinarily there is no pressure in this pipe, the inlet being closed by the check valve. In case of flowage, the pressure will be recorded on the gage and the exact length of time that it occurred can be ascertained from the dial.

CHARGING FOR FIRE PIPES.

In some localities an annual charge is made for sprinkler connections from water-works systems. It might be argued that this is something that should not interest the insurance engineer, but anything that adds to the expense of a sprinkler equipment interests the insurance engineer, for it is his duty to keep the cost of such equipments as low as possible, so that they may be more generally installed and thus cut down the fearful annual fire waste.

Where a water-works system is owned by a town or city and supported by public taxes, there appears to be no more reason for charging for private fire service than for public protection. It may be thought best to make the property owner pay for the original cost of installing such a connection, but it certainly seems wrong to charge him any annual rental. This is, of course, assuming that the fire service pipes are used for fire protection only, as they should be.

The property owner is entitled to public fire protection on account of the taxes he pays. If he chooses to put in at considerable expense private fire protection that will put out a fire

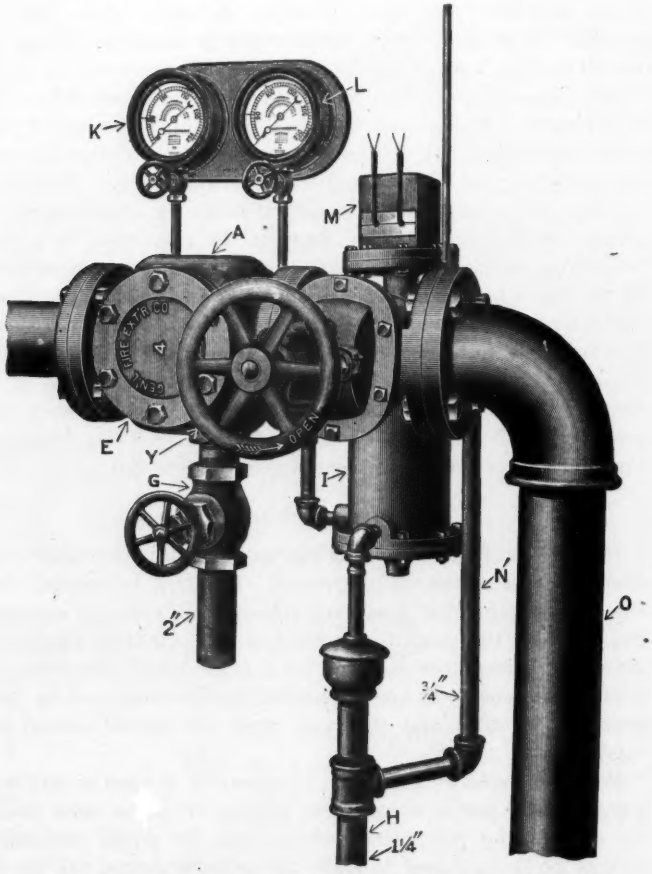


FIG. 5. GENERAL VIEW, GRINNELL VARIABLE PRESSURE ALARM VALVE.

with the use of much less water than would be used by fire department, it is certainly not fair to make him pay the community for so doing.

Where the water system is owned by a private corporation the problem is somewhat different. In this case the town usually

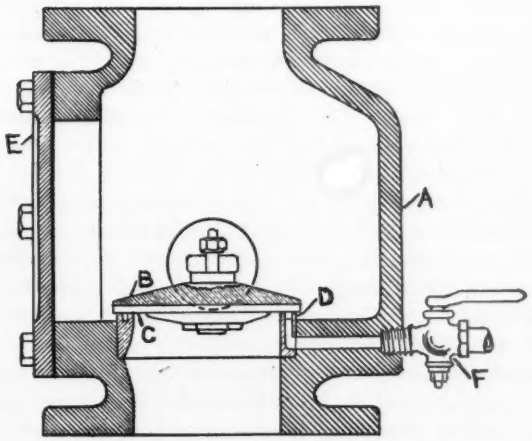


FIG. 6. SECTIONAL VIEW, GRINNELL VARIABLE PRESSURE ALARM VALVE.

The swing check valve *B* when on its seat closes groove *D*. When check opens the water flows through groove and pipe *F* to rotary bell and electric circuit closer (not shown).

pays the water company a given amount per year for each hydrant. Now there seems to be no reason why the private connection should not be placed on the same basis as hydrants in this case, too. If a mill owner should ask for more public hydrants near his plant, they would be supplied without cost to him. If, therefore, he asks for a sprinkler connection which will put out the fire with less water, why should he not be supplied with that, too, at the town's expense? As in the previous case, this is on the supposition that the sprinkler connection will be used for fire purposes only. The regular service connection should be entirely separate. If he desires more yard hydrants, these, too, might be well supplied at public expense, at least, so far as annual rental is concerned, for such hydrants are simply an extension of the pub-public hydrant system, and this he is entitled to if he pays taxes.

Now as to the best basis for payment for fire service connec-

tions where the water system is owned by a private corporation, — for it is certainly fair that some payment be made, whether it be by the town or by the property owner:

In the past, systems have often been charged for on a basis of so much per sprinkler. This is unfair for the reason that sprinklers are installed on the theory that only one floor will be on fire at once. Sprinklers will almost always control a fire before it spreads to another floor, and if they do allow it to spread to this extent, the chances are that they will not control it at all. The same size connection and riser is allowed for a ten-story building as for a one-story building, provided the floor areas are the same. Only so much water can be obtained from a given sized pipe, whether it supplies ten stories or one.

Another method favored by some water companies is to charge a certain proportion of the insurance carried or a proportion of the reduction in rate allowed by the insurance companies for the protection. This is also unfair. It might be that a large part of the insurable value at the plant was in storehouses that contained no fire protection. Again, the reduction in rate for improved fire protection is not based on the protection afforded by public water connections only, but also on private water supplies, such as pumps and tanks, upon private brigades, private hose, watchman's service, and numerous other features.

The fairest basis for the charge would seem to be that of the number and size of connections, for it is this that determines the amount of water that could be used in such a system.

It would seem fair to consider a 4-inch connection as about the equivalent of one hydrant, for this is the smallest size of pipe permitted for a hydrant supply. On this basis a 6-inch pipe would be the equivalent of two hydrants, and an 8-inch pipe to four hydrants, a 10-inch to six hydrants, etc., this being figured on the relative area of these pipes. If, therefore, the price charged per hydrant be taken as a standard, and the sprinkler connection figured on the above basis, we would have a simple method of computation, yet one that is fair both to the property owner and the water corporation.

Finally I would impress upon you the need of coöperating with

the insurance engineer in his campaign to reduce the $500 per minute fire waste of the country. Do nothing that will discourage automatic sprinklers or make equipments more expensive, for in them lies one of the greatest safeguards against serious fires and conflagrations.

DISCUSSION.

MR. ANDREW D. FULLER.* I should like to ask Mr. Dana what the objection would be to metering the fire service where you have a tank.

MR. DANA. There is no objection to metering the supply which fills the tank, but for the supply which goes directly to the sprinklers, of course, the pipes have to be large pipes, 4 to 6 inches, and that means an expensive meter and friction loss and possible clogging in case of fire.

MR. FULLER. Then a person could have a sprinkler system installed, and pay for the amount of water necessary to fill the tank in the beginning, and then, if the direct supply was metered, he would not have to pay for any more water unless there was a fire. Would it not be practical to have the water company buy the large meter and charge a certain amount of rental a year, to cover depreciation, etc.? Would that cost more than the saving in rates?

MR. DANA. Of course it can be done, but what we claim is that it is not necessary, as there are other methods of getting the same results which are cheaper and, from our standpoint, better. We want to keep the cost as low as possible.

MR. CHARLES W. SHERMAN.† What Mr. Dana has said about the parties who pay taxes being entitled to the fullest measure of fire protection seems to call for a little comment. As far as my knowledge of them extends, most public water systems receive no help from the tax levy; they are entirely dependent for their operating expenses and for their contributions to sinking fund upon their water rates. Therefore no taxpayer *as such* is entitled to fire protection, since he is not paying for it. To be sure, the plant belongs to the community, which has loaned its credit for

* Civil Engineer, Boston, Mass.

† Principal Assistant Engineer, with Metcalf & Eddy, Boston, Mass.

the purchase or construction of the plant, but otherwise to all intents and purposes it has no ownership in the system. The water takers are the people who must foot the bills for the operating and maintenance expenses and the contributions to the sinking fund to extinguish the indebtedness.

Now, under those circumstances, as I said before, no taxpayer as such has any right to claim fire protection from the water-works. We are accustomed to furnishing it, and I do not see how we can very well change the conditions which confront us, but as a matter of equity a certain percentage of the necessary running expenses of the water system should be contributed from the tax levy to the water department. That would mean, of course, lower water rates to the private consumers, in order to get an equitable distribution of the operating expense between the water customers and the general public who should pay for furnishing fire protection.

MR. ELBERT E. LOCHRIDGE.* I should like to bring out a point or two in connection with this discussion. As water-works people we have all heard the claims of the insurance engineers, and I think that water-works people in general are anxious to meet them. To carry out Mr. Sherman's point a little further, in any system the revenue is derived from money paid for water used, and the largest consumer in most cases, under the prevailing system of rates, pays the least proportionally; that is, he gets his water cheaper than the small consumer. The fire protection is purely an outside matter, which, in most cases, is not paid for by the municipality except as its credit is loaned, although hydrants and larger pipes must be put in, which are not necessary for the domestic supply but are only needed in case of fire. For that reason it seems to me perfectly fair that people who are directly benefited in their property should pay a certain amount for that particular benefit.

To take up another point, which has not been brought out directly, when the insurance engineer comes to the engineer or superintendent of the water department and asks for these things, he doesn't quite see why it is that we can't grant them, and we don't see why our rules, which are for the benefit, as we see it,

* Chief Engineer, Springfield, Mass., Water Works.

of the entire city, are not as just as their rules; — for instance, their rules that there must be two supplies, and particularly that certain sizes of pipe should be furnished. Now, I want to say that in our reconstruction there have been a number of insurance engineers who have done everything they could to help us and who have arranged their plants in such a way as to insure safety as far as possible; however, there are some who do insist on points of which we cannot see the justice.

For example, two systems of water supply, as has been touched upon here already, are required by the underwriters. The city is under obligation to its citizens to furnish plenty of water for domestic purposes, and to have that water pure. Now, if a fire insurance company insists on two supplies, and allows the insured to pump from the Merrimac or the Connecticut River, or any other supply that is near the plant, as they do, and pump this against a check-valve, doesn't it seem reasonable that the company should also insist that these devices which have been described should be put on? But these are not put on in a great many cases, and so far as we are concerned personally we are having considerable trouble in getting some of them put on. I think we shall succeed in time. There is a constant menace in the testing of the pumps which, as they usually say, they simply turn over, but when you look at their dials you see that they usually go higher than the city pressure, or they do occasionally; and it seems to me perfectly reasonable that if these systems are to be thus connected it should be the duty of the insurance people to see that they are so connected that no impure water should go in for the use of the people employed in the mill or should go to the mains in the immediate vicinity of the mill.

I want to take up, also, not for the sake of argument but for the sake of putting forward the other view, the question of limiting the size of the pipes which go to the fire services. I don't care to consider the question of the actual sizes which should be used, but I think it is perfectly reasonable that pipes should be limited in size, and if greater capacity is needed I think it is perfectly reasonable that more pipes should be installed. If we have in the street an 8-inch main and an 8-inch connection, and the fire spreads beyond the immediate building in which the sprinkler

system is installed, we are under obligation to the other taxpayers and to the other water users to protect their property, and it is a serious thing when a large connection is left open on a street where the gridironing system is not perfect, — and in most of our New England cities it is not perfect in all parts of the factory district. On the other hand, it is probable that with two or more openings they be so placed that even with an advancing fire one of them may be shut off, and it is also possible that as the fire advances both of them may be shut off; and if you can reduce the opening to a 4-inch or a 6-inch instead of having it the full 8-inch, you have gained that much. I believe that the sprinkler system is of great value, and I think that the water-works officials should be ready to meet the insurance people half way, but I believe also the insurance engineers should meet the water department half way in its efforts to meet the demands for pure water, and in its demands that the least amount of water possible should be furnished for private fire protection alone.

Just one other point which occurs to me, and that is that the factories using fire supplies do not willfully take water. I think that the only thing we can fairly say is that they may not *willfully* take it, but if you go about you will see that they do take it, and every water-works man present knows that they take it in pretty large quantities. When we go around with our inspectors we know there are some very decided uses. It seems to me, then, that the insurance engineer should be ready, when asking for the concession of no meters and larger pipes, to furnish such guarantees to the water department that the department would not always be regarding these requests with suspicion, with the knowledge that in the past a great deal of water has gotten by.

MR. DANA. Mr. President, I should like to reply very briefly to Mr. Sherman. The main point in regard to cost and charging to my mind is that of putting private service on the same basis as public service. Whether or not an abutter should pay for hydrants I do not know, and I am not discussing that; but I do claim that if he does not pay for hydrants he should not be asked to pay for a connection to his building which will put out a fire with less water than he would take from the hydrant.

MR. EDWIN C. BROOKS.* Mr. President, I have sometimes thought that some of the trouble in regard to sprinkler systems might be solved by putting in composition check valves. The body of a check valve, as ordinarily made of cast iron, is barely large enough to let the valve operate, and the least formation of tubercles on the inside of the body is liable to arrest the opening or closing. Now a composition check valve would not be a very expensive luxury, and it seems to me it would be a step in the right direction in solving the trouble arising from check valves sticking open. Any one who has ever had much experience with check valves knows that they are an invention of the devil, and at best they are a very poor contrivance.

MR. EDWARD V. FRENCH.* Mr. President, I used to come here simply as an insurance man, and I got pretty good treatment then, though generally not a great deal of agreement. I am glad to come to-day more as one of the brotherhood, for as one of the members of the Water Board down in Lynn I think I have had enough trouble during the last year or two to feel pretty secure in the ranks, — and the trouble is not over.

I would like to emphasize a little one point which Mr. Dana made in answering Mr. Sherman. Mr. Sherman's points are, I think, entirely right, if you analyze this question of charges for fire service down to the final limit, but his suggestions are not feasible, apparently, under present conditions of organization, as Mr. Sherman himself really intimated. I have brought up this illustration before, but I think it makes the thing clear. Take any one of our cities, and suppose at one end of the city there is a manufacturing plant that has no fire protection of its own, and simply depends on the public water supply. If that establisbment gets on fire, there isn't anybody here who questions that it is the duty of the public fire department to go down there and throw water on that plant for six or eight hours, or longer if necessary, and to use all the water that they can get; and frequently, where the fire has to be extinguished by such methods, the amount of water used is large. Now, supposing at the other end of the same city there is a progressive sort of a manufacturer, who has listened to some of the

* Vice-President Arkwright, Mutual Fire Insurance Company, and member of Water Board, Lynn, Mass.

ideas of men like Mr. Dana and put in private fire protection. If he has a plant that is worth $500 000, the chances are that he will have spent $20 000 of his own money for fire protection. He goes to the city and asks merely for a connection to supply his sprinklers with water, and immediately there is a desire to charge an annual amount for the service. Now the fact is that this manufacturer after spending his own money for protecting his plant is very much less likely to use any considerable amount of water than the man at the other end of the town who has no protection whatever. So that, as a matter of equity, with our present method of charging, it really is not fair to charge a man who is progressive enough to put in a fire equipment, which means merely better tools for using the water that is there, and let the man at the other end of the town have all the water that can be thrown on his plant without making him any charge whatever.

I am perfectly ready to agree — and I wish in our own case we could get something out of the tax levy—that it would be equitable to have the water department paid so much from the city funds for the fire service which it renders. Until that can be done, however, it isn't really fair and equitable to ask a large yearly payment from the man who puts in protection for the connection he desires to supply his equipment, and let the other man who perhaps does not pay any more to the water department get his fire protection perfectly free. It is simply a question of the equity of the thing under the present imperfect arrangement of charges.

Now just a word as to what Mr. Lochridge has said. I generally agree pretty well with Mr. Lochridge, and I think we will agree in this case. The real cardinal point about the sizes of connections is this: In order to make the sprinkler equipment at all efficient, you have got to furnish a fair amount of water at the outset of the fire. Fires that open 25 to 50 sprinklers are not uncommon. I have a list here of a good many fires in the last year and a half which opened over 25 sprinklers. Now 15 gallons per sprinkler is about the minimum, so that 50 sprinklers would take 750 gallons,— and we have rather taken for the average size plant 750 gallons a minute as about a fairly good water supply, if it can be delivered at a pressure of, say, 10 or 15 pounds at the highest head while the

sprinklers are discharging. If you stop to figure you will find that a 4-inch pipe, which will generally be 50 feet long between the street main and the fire service, together with the check valve and a gate and perhaps one or two elbows, will cause a loss of about 25 pounds pressure with 750 gallons per minute flowing. If, on the other hand, the service is 6-inch, the pressure loss comes down to a few pounds. Again, if you have a larger plant which may require, say, 1 500 gallons a minute, the loss in a 4-inch pipe would be in the vicinity of 100 pounds, which is absolutely prohibitive.

I agree fully with Mr. Lochridge that it is the duty of the water department to safeguard the whole system, but you never can do it perfectly, or even very efficiently, by simply putting in small-size connections. I think the rule should be to limit the connection reasonably to a size which would give the water needed in the particular case, and then get safety by requiring such a location of these connections and such controlling valve, that the valve can be gotten at and the water shut off in case the building falls.

In a great many factory plants the water goes into a system of yard pipes and is there distributed to the buildings, and every sprinkler connection has an outside valve, so that all use of water can be controlled. In the more compact sections of a city where there are built-up districts, so that you cannot do this, I think it would be possible for water departments, and perhaps this Association can help in that line, to develop some standard method of outside valves, marked in some standard way, so that it would be known as an outside controlling valve, and then locate those with a little study in each special case, so that they could be reached properly. This, I think, would give the protection needed, and is really the only way to get it in a thoroughly safe manner.

Mr. Brooks brought up another interesting point, which Mr. Lochridge touched on also, and that is the check-valve and its diabolical origin. I think he is entirely right about it. We have given this much study, and it is possible to get a check-valve of better design, with more clearance, so that tubercles cannot easily obstruct it, and with better hinges, etc. We have given a good deal of attention to having such a check put on the market and are using such improved patterns in places where there is

* Superintendent of Water Works, Cambridge, Mass.

danger of pollution. In cases where the danger is considered serious we are putting in two checks in series, one after the other, and putting them in a pit so that they can easily be kept in order. I believe in this way the conditions can be made very safe. The underwriters are ready to meet water-works men on all these matters, and fully appreciate that our interests are identical. I believe it will be seldom, when we get together in this way, on most anything except meters, that we shall fail to work out the problem in a manner satisfactory to all interests.

MR. JOHN H. FLYNN.* I had occasion not a great while ago to go to a place where they had all these devices which have been spoken of, and the owner laid great stress on the fact that he had wonderful protection because he had three 4-inch pipes going into his building. Two of them, however, were found to be shut off out in the street, and had been for three years; in fact they had never been opened.†

MR. M. F. COLLINS.‡ Mr. Dana has told us here to-day that where there are two sources of supply run into a building the cost of insurance is at the minimum. Now, if in a case where two supplies go into a building, we will say the high and the low service, the parties get their insurance reduced to such a low figure, why shouldn't they be willing to pay for one of the services, when they have two and it reduces their cost of insurance so much? I know of a case in our city where the owner of the building wanted to get the high service put in for nothing, and he was frank enough to tell me that it would bring his insurance down $600 a year, and notwithstanding that he wasn't willing to pay a yearly rental of $25 for a 4-inch connection. I should like to have Mr. Dana explain that.

MR. DANA. I don't know why a high and low service supply should be any different from a single service; the principle is the same. The question is why you should want to make a man pay for putting a system in his building which will extinguish a fire with less water than would be used from the hydrants. I

* Assistant Superintendent, Boston Water Works.

† (*Note by* MR. DANA.) It was supposed that these valves had been left open by the water department, and the discovery that they were closed was made by an insurance inspector.

‡ Superintendent of Water Works, Lawrence, Mass.

don't see that it makes any difference whether he has one or two connections.

MR. COLLINS. In the case to which I refer, the man had the low service system in, and the high service was extended down through the business portion of the town at the expense of the public. There was a special appropriation made; the money for the extension was not taken out of the water department. He had all the protection that it was originally intended anybody should have by the low service, which gave in the neighborhood of 65 or 70 pounds pressure; but he asked for the other to be put in on the ground that it would reduce his insurance. Now, if it reduces his insurance why shouldn't he be compelled to pay for it, and why should the insurance engineers be so particular to look after his interests rather than to look after the interests of the water department?

MR. DANA. I think the same argument will hold, that as matter of principle it doesn't make any difference whether there is one or two services. The question is, if that high service is put in for fire protection, why he hasn't as much right to use it as the next man has. It would be used in case of fire anyway, and if he has a sprinkler system connected with it he will use less water in case of fire than if he hasn't.

MR. COLLINS. That doesn't answer the question. My question was, why shouldn't he be willing to pay for the double system, as long as he gets a reduction in his insurance rate? If he gets a reduction of $600 a year in that, why shouldn't he be willing to pay a proportionate part of the expense that the city has to pay?

MR. DANA. Simply because the high service is put in for public protection.

MR. COLLINS. But it isn't public protection when he gets it inside his own building.

MR. DANA. I don't know why it isn't. If the water puts out any fire it has to go inside the building, of course.

MR. FLYNN. I have a case in mind where a building fell down and carried the pipe with it. It fell down in front of the stairway leading up into the building, and there was a 6-inch pipe running up that stairway. The side walls of the building fell

down and covered the gate in the street, and it was three days before they got the brick away from it, and of course the firemen had gone home long before that. It seems to me that there was a loss there

MR. DANA. You should have your valve in the street, so you can shut it off from the street.

MR. FLYNN. But we couldn't get at it, because the side wall of the building fell over and covered it up with about 20 feet of brick.

MR. DANA. They couldn't get at the valves after the San Francisco earthquake, but such cases don't happen very often.

MR. FLYNN. We have to look out for the one case that does happen, — that is when we are proficient in our business.

MR. DEXTER BRACKETT.* I should like to ask the insurance engineers if they think it would be practicable to shut off fire pipes during the progress of a large conflagration in the business section of Boston, on Washington Street, for example, or on any of the streets that are solidly built upon, in case the buildings were destroyed. It does not seem to me that it would be, and I think there is considerable to be said from the standpoint of the water-works superintendent who objects to putting in pipes of a large size for sprinkler service. The conditions must be taken into account. The conditions that are met by the Manufacturers Mutual Fire Insurance Company, and by other companies that insure largely mill property, where they have yard room in most cases, are entirely different from what they are in a thickly settled city. The quantity of water that is demanded for the sprinkler heads on one floor would be a small part of the quantity of water which would be discharged from a 4-inch or 6-inch main if the building burned, and under those conditions it is probable that the fire service in the immediate neighborhood would be crippled.

The remedy for this may be to have an entirely independent system of street pipes for supplying standpipes and sprinkler systems, independent of the domestic and hydrant service, and this has already been done in the business portion of the city of Boston. Wherever the property is of sufficient value to warrant

* Chief Engineer, Metropolitan Water Works, Boston, Mass.

this expense, it can be done. But I do not believe that the water-works authorities are warranted in crippling the system for the benefit of one comparatively small manufacturer. It may be a question of the comparative value of property. If the property to be protected is a plant worth $1 000 000, and property in the immediate neighborhood is worth but a few thousand, it may be policy to carry one or more 6-inch pipes into a building for supplying sprinklers, but I doubt the desirability of doing this in all cases.

MR. DANA. Mr. President, in reply to that I would simply suggest that the main point in the use of sprinklers is to prevent a fire from getting large, and we hope some day to have the cities in such shape that we won't have the large fires. When we get the buildings either all fireproof or all equipped with sprinklers, then we won't have any fires which will necessitate shutting off a connection.

MR. GEORGE CASSELL.* I am one of the very few men who have had a very wide and sorrowful fire experience. I want to ask Mr. Dana if he thinks the sprinkler system would have had the effect of putting out such a fire as struck my city [Chelsea, Mass.] on the 12th of April last?

MR. DANA. I don't think it would after the fire got well started, although a brick building properly equipped might have checked it in a certain direction. Sprinklers are supposed to prevent it getting started. The Brown-Durrell building in Boston was equipped with sprinklers and checked the big fire of March 10, 1893, which, but for this, would have undoubtedly been a conflagration.

Automatic sprinklers, together with open (window) sprinklers and blank walls, saved the O'Neill department store in the Baltimore fire and assisted in preventing the spread of the conflagration.

MR. CASSELL. That is just the point, "supposed." The inevitable is going to happen.

MR. DANA. Not when you get your whole city equipped.

MR. CASSELL. You couldn't have stopped a fire of that kind if you had had all the sprinkler systems and all the steamers in Massachusetts and an Atlantic ocean of fresh water.

* Superintendent of Water Works, Chelsea, Mass.

MR. DANA. You could if you had had sprinklers in the building where it started.

MR. CASSELL. But, my dear sir, you see you use that little word "if." There is the stumbling block, the "if." It did happen, didn't it?

MR. DANA. Yes, sir.

MR. CASSELL. It did; and that substantiates my position.

MR. DANA. What have you done since? You have required that all rag shops hereafter built in Chelsea shall be equipped with sprinklers, in order to prevent it happening again.

MR. CASSELL. That is the law, to be sure, and that brings up another point. You have said to the gentlemen gathered here this afternoon that you have laws governing fire protection systems; and so we have laws in our city, newly made and old, for the protection of property from fire; but the trouble is they are not enforced. Now, if your company, or whoever is interested — and there is a wide field for improvement —will get the coöperation of all the insurance men, and people who install the sprinkler systems, to adhere strictly to your rules and to our rules, we would all be much better off; but experience shows there is very little attention paid to them by some of the insurance people. They come into my city and they think that they are licensed to go into any place where there is a sprinkler system and do just as they please. I am not saying that you are to blame, nor that you are cognizant of the facts, but these are facts. And they had carried it to such a degree that a short time ago I brought some of them before the court and had them fined.

I am only citing this to show that if that hearty coöperation in all things of which you speak,— and by the way, you don't tell our side of it, you only tell your side of it, — if that hearty coöperation in all things pertaining to water supplies was entered into by the insurance people and the water-works people, we could get together and formulate some plan which would be of benefit.

I am glad Mr. Brackett spoke as he did in relation to private fire supplies, because we are well acquainted with the past, and we have had that up in our city, and while we are desirous of doing everything we possibly can do, not only for the corporations but

for the individuals, there is a point at which, when we arrive at it, we must stop. While we are willing to coöperate with the insurance men in furnishing a private fire supply that will not cripple the public supply in the vicinity, when it comes to their asking for something that has a chance to work an injury to the rest of the citizens, there we draw the line. And I say, and say it decidedly, that when the insurance people ask a water-works man to give them a supply of water from a main, in a district not perfectly grid-ironed, that is equal to the capacity of the main in the street, the man who gives it to them is putting himself in a position to be severely criticised in case of a serious conflagration.

Now, if the insurance people will pay more attention to their own rules and to our rules, they will help us out greatly. For them to make plans for the installation of a private system for a big factory in a city, go ahead with it, and then after they have finished it all come to the water office and ask for a connection, without having found out what our rules and regulations are, I say it is not right. They should come first and get the rules and regulations and the requirements of the city, and not get into trouble and then come and try to force the water department employees or officials to help them out by giving them something that is liable, and very much so, to be to the detriment of the other citizens who are entitled to fire protection.

MR. DANA. Mr. President, in reply to Mr. Cassell, I will state that the principal reason why I am here to-day is to tell you our rules and to learn your rules and to help bring about better coöperation. I am sure we are always ready to comply with any reasonable rules, but the point is that we think some of your rules are unreasonable.

MR. CASSELL. And I think we have greater reason to believe that some of your rules are unreasonable.

THE PRESIDENT. It seems to be the same old question between the insurance men and the water-works superintendents. We have had it up before and are liable to have it up again.

MR. COLLINS. Mr. Dana in his paper spoke of going into some city, if I understood him correctly, and finding 200 gates closed.

MR. DANA. Oh, no; that was not in one city; that was a year's

record in the whole of New England. They were private valves inside of buildings.

MR. COLLINS. Well, let me give you an idea how that may have happened. One day I was riding down Canal Street in our city and I saw a man closing a gate on the street. I pulled up my horse and asked him who he was, and he informed me that he represented the underwriters. I told him who I was, and said, "If you want to operate any of our gates it is our duty to furnish a man to go around with you." He said he wanted to make sure they were all right. I told him that where the authority was divided between the city officials and the mill officials nobody was responsible, and if he wanted to see anything we would give him all the help he needed; but if he went around and operated the gates and closed some of them and left some of them closed, I didn't think it would be the insurance company which would be held responsible, but the water department. So I was wondering whether in those cases of which Mr. Dana spoke it might as likely be the insurance men as the water-works men who were responsible.

MR. DANA. I think you were right; the man had no right to touch the gates without a water-works man present.

MR. GEORGE A. STACY.* I remember a somewhat similar instance in my town, Mr. President. A man who had charge of a large storehouse came to me one day and said, "We haven't got a main gate wrench up there at the storehouse." I said, "I didn't intend you should have; what do you want it for?" He said, "There is an insurance man here and he wanted to go out and try your gate on the street to see if it was open." I said, "He cannot, unless I go with him." "Well," he said, "the man said there ought to be one there so he could try the gate at any time."

I don't say this as a criticism of all insurance people, but there are some of them going around who, I think, haven't been in the business a great while. I have found the majority of them nice people to deal with. This young man wanted to take a wrench and go out unbeknown to me and handle one of my gates, and I told him, "Any time that the insurance people want to investigate any part of the works, if they will simply notify this de-

* Superintendent of Water Works, Marlboro, Mass.

partment we will drop everything and accommodate them to the best of our ability. They can open and close them as much as they like, but we want to be there when it is done." I think that is reasonable and right. I think he had no business to ask for that wrench, or to go and handle the gate, without me or my representative being there. That creates friction.

Every factory in our city is sprinklered, and there hasn't been an instance yet where the sprinklers haven't done their work, and I know of three or four pretty good-sized structures in the city of Marlboro which, there is no question in my mind, would not be standing there to-day if it wasn't for sprinklers.

On the subject of check valves, I have been interested in what has been said here. In the upper part of the city we have two systems, high and low, and I was rather in doubt how I was going to handle the question when they wanted both pressures available in the factories for their sprinkler service. We believe in doing everything that we can to secure lower insurance rates for our manufacturers, so long as we can do it without crippling the works; so we laid two service pipes, one from the high and one from the low, and put check valves into one outside the building. Those check valves were made by a firm not a great way from Boston. They were put in some years ago; there are quite a number of them; they have been tested many times and they have always worked and been perfectly tight and reliable.

There is one thing more which I recall, that occurred a long while ago, — I suppose they have got beyond that now, and I wouldn't question for a moment the ability of an insurance engineer of the present day to tell what the capacity of a pipe should be, — but there was this one very peculiar thing, that occurred perhaps fifteen years ago, in the upper part of the city, where there was 30 or 35 pounds at that time on the main; they wanted a 4-inch pipe for the sprinkler system, and later, perhaps two or three years afterwards, in the lower part of the city, where there was 95 pounds, for the same service,— practically the same size building with the same number of sprinklers,— I had to put in, or did put in, on request, a 6-inch pipe. I never could reconcile that. I don't mean to say that the insurance people didn't understand what they were doing, but those are the facts.

In regard to a second connection, we have always required the manufacturer to pay for it, and he has always done it willingly. In one case we went through three feet of frost to get the second pipe in by the time the insurance under the one-pipe system expired, and they were willing to pay the extra cost. We haven't had any trouble with our connections or our sprinklers or with the insurance men, except in a very few cases where I think anybody would say they were a little unreasonable. There is very little friction between us, and I think the time is coming when we will all get together. I think we are nearer on this matter of fire service pipes than we were, and everything will come out all right if we have a little patience and keep on with our discussions. I think we are coming to learn more every time we talk these matters over. I think the insurance men are learning, I won't say more than they now know, but a little more about our position, and we are learning a little more about theirs.

PROCEEDINGS.

NOVEMBER MEETING.

HOTEL BRUNSWICK, BOSTON, MASS.,
November 11, 1908.

President Alfred E. Martin in the chair.

The following members and guests were present:

MEMBERS.

S. A. Agnew, A. F. Ballou, L. M. Bancroft, G. W. Batchelder, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, George Bowers, Dexter Brackett, E. C. Brooks, George Cassell, J. C. Chase, C. E. Childs, F. L. Clapp, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, J. H. Cook, G. W. Cutting, Jr., Gorham Dana, E. D. Eldredge, J. H. Flynn, F. F. Forbes, A. N. French, E. V. French, A. D. Fuller, F. L. Fuller, D. H. Gilderson, T. C. Gleason, A. S. Glover, F. H. Gunther, F. E. Hall, T. G. Hazard, Jr., H. G. Holden, J. L. Howard, C. L. Howes, W. S. Johnson, J. W. Kay, E. W. Kent, Willard Kent, G. A. Kimball, G. A. King, L. P. Kinnicutt, H. O. Lacount, E. E. Lochridge, N. A. McMillen, D. E. Makepeace, A. E. Martin, John Mayo, F. E. Merrill, H. A. Miller, William Naylor, F. L. Northrop, H. L. Newhall, E. M. Peck, J. H. Perkins, L. C. Robinson, A. L. Sawyer, E. M. Shedd, C. W. Sherman, G. H. Snell, G. A. Stacy, G. T. Staples, J. T. Stevens, W. F. Sullivan, R. J. Thomas, D. N. Tower, W. H. Vaughn, R. S. Weston, J. C. Whitney, F. I. Winslow, G. E. Winslow. — 72.

HONORARY MEMBER.

William T. Sedgwick. — 1.

ASSOCIATES.

Harold L. Bond Company, by Harold L. Bond; Central Foundry Company, by J. H. Morrison; Chapman Valve Manufacturing Company, by E. F. Hughes; Hersey Manufacturing Company, by Albert S. Glover; International Steam Pump Company, by Samuel Harrison; Ludlow Valve Manufacturing Company, by H. F. Gould; H. Mueller Manufacturing Company, by George A. Caldwell; National Meter Company, by J. G. Lufkin; Pittsburg Meter Company, by F. L. Northrop; Rensselaer Manufacturing Company, by Fred S. Bates and C. L. Brown; Thomson Meter Company, by E. M. Shedd; Water Works Equipment Company, by W. H. VanWinkle, G. W. Browne, and W. H. VanWinkle, Jr. — 15.

GUESTS.

John McKay, chief engineer, and Charles Rennie, chief inspector, Brooklyn water works, Brooklyn, N. Y.; T. Easten, chairman water board, and I. M.

Lowe, superintendent, Weymouth, Mass.; L. H. Camfel, Boston; W. M. Collins, M.D., and James E. Donnelly, Lowell, Mass.; R. W. Carter, water commissioner, Maynard, Mass.; J. A. Jones, superintendent, Stoneham, Mass., and Dr. H. D. Pease, director State Hygienic Laboratory, Albany, N. Y. — 10.

[Names counted twice — 3.]

Henry Roberts, of Hartford, Conn., president and superintendent of the Hartford water works, his application having been properly endorsed and acted upon, was elected a member of the Association.

Mr. Gorham Dana, manager of the Underwriters Bureau of New England, Boston, Mass., presented a paper entitled "Private Fire Protection and Insurance Rules." The paper was discussed by Messrs. Andrew D. Fuller, Charles W. Sherman, Elbert E. Lochridge, Edwin C. Brooks, Edward V. French, John H. Flynn, Dexter Brackett, George Cassell, and George A. Stacy.

Dr. H. D. Pease, director State Hygienic Laboratory, Albany, N. Y., presented a paper entitled, "Public Water Supplies of the State of New York," which was discussed by Messrs. Robert S. Weston, Wm. T. Sedgwick, Elbert E. Lochridge, and Leonard P. Kinnicutt.

Adjourned.

EXECUTIVE COMMITTEE.

NOVEMBER 11, 1908.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple.

Present: President Martin and members George A. King, D. N. Tower, Robert J. Thomas, George W. Batchelder, M. F. Collins, William F. Sullivan, Charles W. Sherman, L. M. Bancroft, Willard Kent, and George A. Stacy.

James R. Fitzpatrick, general manager Grand Rapids and Hydraulic Company, Grand Rapids, Mich., was reinstated to membership.

Application of Henry Roberts, president and superintendent Hartford water works, Hartford, Conn., was received and he was recommended for membership.

The Secretary was appointed a committee to investigate and report on Bangor as a place for holding the next annual convention.

WILLARD KENT, *Secretary.*

REPORT OF COMMITTEE ON EXHIBITS AT CONVENTION.

NOVEMBER 5, 1908.

WILLARD KENT, *Secretary,*

NEW ENGLAND WATER WORKS ASSOCIATION:

Sir, — The Committee on Exhibits at the annual convention at Atlantic City, hereby makes the following report.

Eighteen associates availed themselves of the opportunity to exhibit goods as follows:

International Steam Pump Company . . .	Worthington meters.
Anderson Coupling Company	Lead connections.
Water Works Equipment Company	Tapping machines, etc.
H. Mueller Mfg. Company	Water-works specialities.
National Meter Company	Meters.
Hersey Mfg. Company	Meters.

Neptune Meter Company	Meters.
National Water Main Cleaning Company	Samples of pipe.
Builders Iron Foundry	Venturi meters, etc.
Lead-Lined Iron Pipe Company	Lead-lined pipe and fittings.
Pittsburg Meter Company	Meters.
A. P. Smith Mfg. Company	Tapping machines, etc.
Thomson Meter Company	Meters.
East Jersey Pipe Company	Lock-bar steel conduit pipe.
Union Water Meter Company	Meters.
Ross Valve Mfg. Company	Regulators, etc.
Hays Mfg. Company	Water-works specialities.
Fairbanks' Company	Scales, hydrants, and valves.

Eighteen exhibits, occupying 500 square feet of space.

Respectfully submitted,

EDWARD F. HUGHES.

OBITUARY.

ARTHUR W. HUNKING died at Helena, Mont., on November 12, 1908, after an illness of a few days.

Mr. Hunking was born in 1851, in Haverhill, Mass. After graduating from the Haverhill High School he took the civil engineering course at the Massachusetts Institute of Technology. His first professional engagement was with Mr. Clemens Herschel, who then had his office in Boston, but he soon joined the staff of the Locks and Canals Company at Lowell, and, except for a year or two spent in the service of the Holyoke Water Power Company, was with that company until 1890. His later service was with the Stillwell-Bierce & Smith-Vaile Company, the Manufacturers Mutual Fire Insurance Company of Philadelphia, and the Massachusetts Cotton Mills in Georgia. In 1905 he became connected with Stone & Webster, of Boston, and was engaged on various water-power development work for them to the time of his death.

He was elected a member of the New England Water Works Association, June 11, 1890.

J. O. A. LAFOREST died December 28, 1907. He was born at Joliette, Quebec, in 1867, and graduated in 1885 from L'École Polytechnique in Montreal He was first employed as an engineer upon the Great Northern Railway of Canada. In 1889 he became assistant engineer of the Montreal Water Works, and in 1894, general superintendent, holding this position for six years. Later he was engineer in charge of construction of water works at a number of towns in Quebec, and from 1903 to 1907 he was in charge of harbor works at Louise Basin, Quebec. He was a member of the Canadian Society of Civil Engineers.

Mr. Laforest became a member of the New England Water Works Association, December 14, 1892.

CLAUDE PENDLETON NIBECKER, sanitary engineer for the American Water Works and Guarantee Company, died in Pittsburg, Pa., November 10, 1908.

He was born at Westerly, R. I., September 19, 1881. He was graduated from the Massachusetts Institute of Technology in 1903, and immediately thereafter was employed on the experimental filters of the Springfield, Mass., water works. At the close of this work he was engaged by the American Water Works & Guarantee Company, and remained with this company until his death.

Mr. Nibecker was elected a member of the New England Water Works Association on November 14, 1906.

BOOK REVIEWS.

SEWER CONSTRUCTION. By Henry N. Ogden, Professor of Sanitary Engineering, Cornell University. 6 x 9 inches, xii + 335 pages. New York: John Wiley & Sons. Price, $3.00.

This book is supplementary to the author's "Sewer Design," which was published in 1899, and is the result of a course of lectures given to students in civil engineering at Cornell University. It is, therefore, to a large extent, of an elementary nature, but is intended to be, and unquestionably will be, useful to practicing engineers who are for the first time taking up sewer construction work, as well as to students.

Some idea of the contents of the book may be obtained from the titles of the chapters, which are as follows: Terra-Cotta Pipe, Terra-Cotta Pipe (continued), Brick Sewers, Concrete Sewers, Concrete and Brick Sewers, Reinforced Concrete Sewers, Manholes, Catch-Basins, Siphons, Screens, Storm Water Overflows and Regulators, Bell-Mouths, Foundations, Outfall Sewers, House Connections, Surveying, Trenching, Estimates and Costs, Specifications and Contracts.

The treatment of the several subjects is as full as could be expected for students' use, but the practicing engineer would desire somewhat further information on some points, particularly on the design and construction of forms for concrete and reinforced concrete sewers. Some of the statements relating to rapidity of work, too, seem to have been based upon experience prior to the adoption of the eight-hour day, and are hardly applicable to present conditions, at least in New England.

The book is not only well adapted, as a whole, for the classes for whom it was especially prepared, but is well worthy of the perusal of engineers who are actively engaged in this class of work; most of them will find suggestions or ideas which are new or helpful to them.

RESERVOIRS FOR IRRIGATION, WATER POWER, AND DOMESTIC WATER SUPPLY. By James D. Schuyler. Second edition, revised and enlarged. 573 pp. 6¾ x 10 inches. 381 illustrations, 6 plates. New York: John Wiley & Sons, 1908. $6.00.

This second edition of Schuyler's "Reservoirs" has been much enlarged and largely rewritten. The demand which has resulted in the revision is an evidence of the favor with which this work has been received. The reviewer heartily welcomes the new edition, which contains a great deal of information not easily obtainable elsewhere, and of great interest and value to all who have to do with the design, construction or maintenance of dams or reservoirs. And yet there are many things that may be criticised.

In the first place, the book might more properly be entitled "Dams and Embankments," since it treats almost exclusively of those subjects. Very, very little is said about reservoirs, and nothing whatever about the relative advantages of deep and shallow reservoirs, necessity or otherwise of clearing, grubbing or stripping, estimation of capacity, or other subjects relating to reservoirs rather than dams. Indeed, the chapter titles and section headings are almost invariably *dams*.

The chapters are as follows: Rock-Fill Dams, Hydraulic-Fill Dams, Masonry Dams, Earthern Dams, Steel Dams, Reinforced Concrete Dams, Natural Reservoirs, Miscellaneous.

The basis of the book is a large number of illustrations, largely reproductions of photographs of dams, with a reasonable number of cross-sections and plans, and with comparatively brief sections of descriptive matter. Something like 300 dams are thus described. In some cases the descriptions are fairly detailed, and cover several pages.

There does not seem to be any logical scheme of arrangement of either chapters or sections. The several matters are not treated in chronological order, nor are they grouped at all closely by types or forms. Thus we find gravity and arched masonry dams mixed indiscriminately in the chapter on masonry dams. There are also certain peculiar arrangements, such as inserting a plate showing irrigation canals near Phœnix, Ariz., in a description of dams in Old Mexico; a map of sources of water supply near San Diego, Cal., in text describing dams in India; a cut of the cross-section of the earthern part of the Ashokan dam, without description, in the chapter on Masonry Dams, etc.

The book is made up almost wholly of statistical data and contains very few comments or criticisms upon any of the works described. It would seem as though its usefulness might be largely increased by an analysis of many of the structures, showing wherein their strong and weak points lie, and why they do or do not represent good practice. Some matters which would be of great interest, such as the flood which Professor Williams's Ithaca dam successfully withstood during construction, are not mentioned.

With all this, however, this book contains an immense amount of valuable information and should have a place in the library of every hydraulic engineer. The plates showing comparative sections of the more important masonry dams all over the world, drawn to a single scale, and similar sections of a few large earthern dams, and the table giving cost of reservoir construction per acre-foot of capacity, are especially valuable. It would seem that this table might well be extended by the addition of another column showing the cost per million gallons of capacity, for the benefit of eastern engineers, who never have occasion to work in acre-feet.

Some doubt is, however, thrown on the accuracy of this table by the fact that the cost of the Wachusett Reservoir is here taken as the cost of the Wachusett dam only, neglecting not only the cost of stripping and preparing the reservoir bottom, — which might perhaps well be omitted in a comparison with other reservoirs where no such preparation was made, — but also

the cost of the two dikes, which in effect constituted sections of the dam, equally necessary as the main dam in the construction of a reservoir of the capacity stated.

Most of the illustrations are very good. The book is well printed on good paper, and, considering that it is in effect a new book, contains few typographical errors. It has a good index.

PUBLIC WATER SUPPLIES. By F. E. Turneaure and H. L. Russell, professors in the University of Wisconsin, with a chapter on Pumping Machinery by D. W. Mead, professor of Hydraulic and Sanitary Engineering, University of Wisconsin. Second edition, revised and enlarged. 808 pp. 6 x 9 inches. New York: John Wiley & Sons. 1908. $5.00.

The first edition of this book appeared in 1901; it has now been revised and brought up to date in illustrating the best modern practice in water-works engineering. The changes in current practice since the first edition have, of course, been most marked in water purification works, but are also of considerable moment in all branches.

This book is primarily a textbook, and a most admirable one. It is designed especially for the use of students in engineering schools. It is, however, none the less valuable as a book of reference for the practicing engineer and water-works man.

To even list the contents of this work as indicated by the chapter headings would occupy more space than is available for this review. It may be stated that the whole subject of water-supply engineering is covered as fully as is possible in the space available, starting with an historical sketch of the development of water-works systems; following with an outline of the quantity of water required and sources of supply; quality of water and examination of supplies; the general principles of water-works design (including a chapter containing substantially all the formulas of hydraulics which are likely to be needed in such works); descriptions of works for the collection, purification, and distribution of water, including pumping machinery; and a few remarks upon general financial considerations in the operation of water works. It may be noted that the application of the principles of economy in the problem of design is also discussed with a reasonable degree of fullness.

Periodical literature has been drawn upon in large measure in preparing much of the matter. It is a satisfaction to note many references to the JOURNAL of this Association, and particularly that the patterns of the Association's Standard Specifications for Cast-Iron Pipe and Special Castings are quoted in some detail. The references are very full, both in the text and in the bibliography which is appended to each chapter.

The book is well illustrated, mostly by reproductions of drawings. The typography and paper are good and the makeup of the volume in every way satisfactory. It is by all odds the most comprehensive and satisfactory single book upon the subject of water works published in the United States, and should be in every water-works library.

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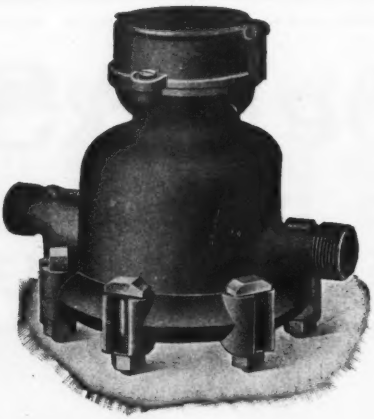

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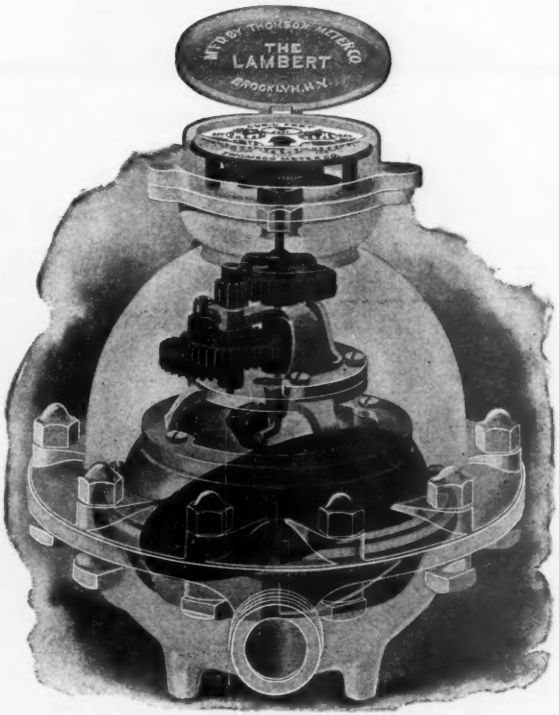

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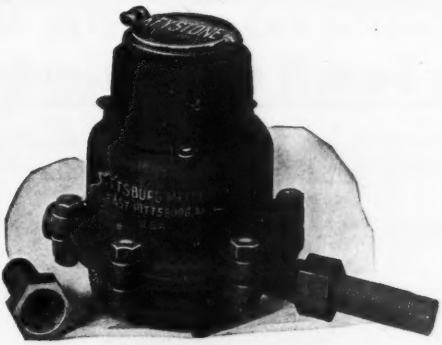

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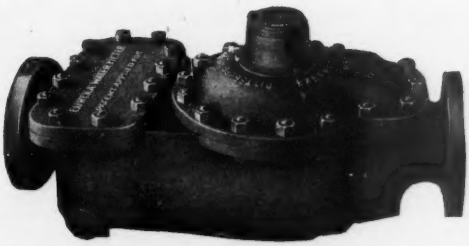

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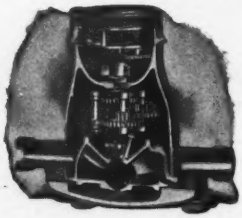

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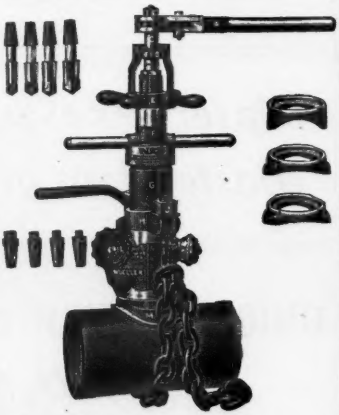

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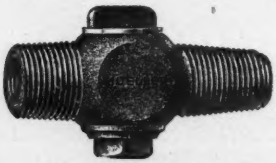

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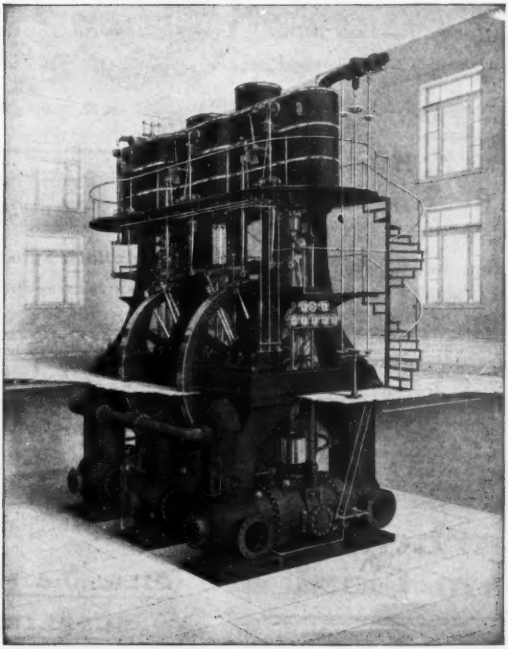

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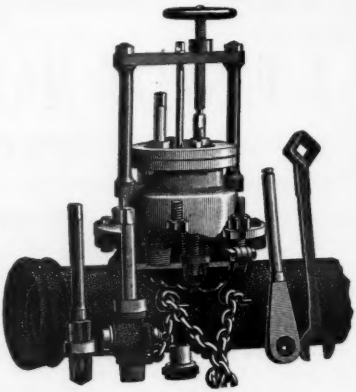

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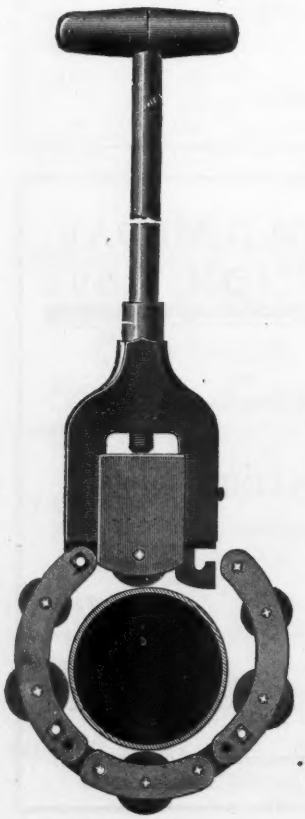

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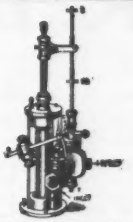

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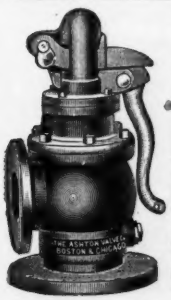

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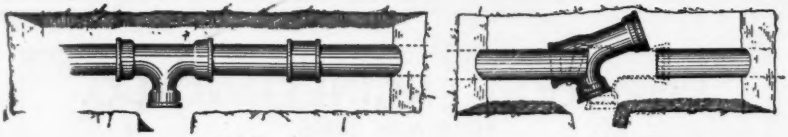

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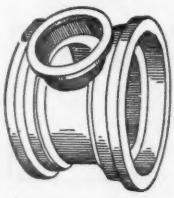

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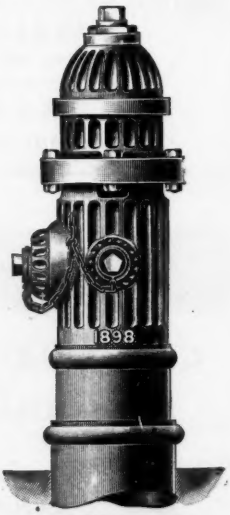

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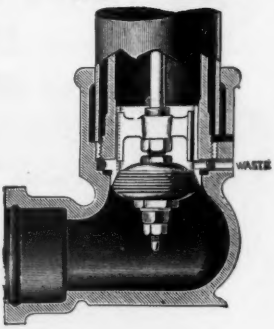

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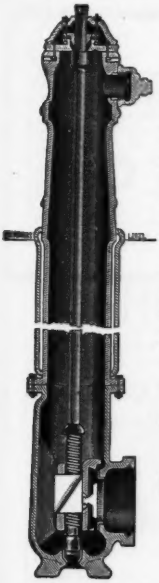

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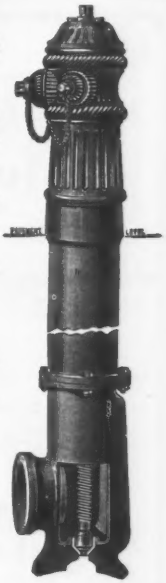

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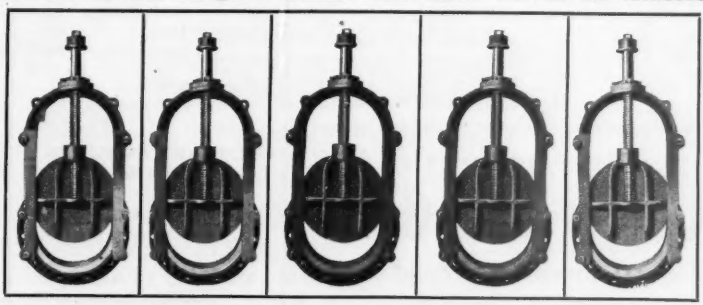

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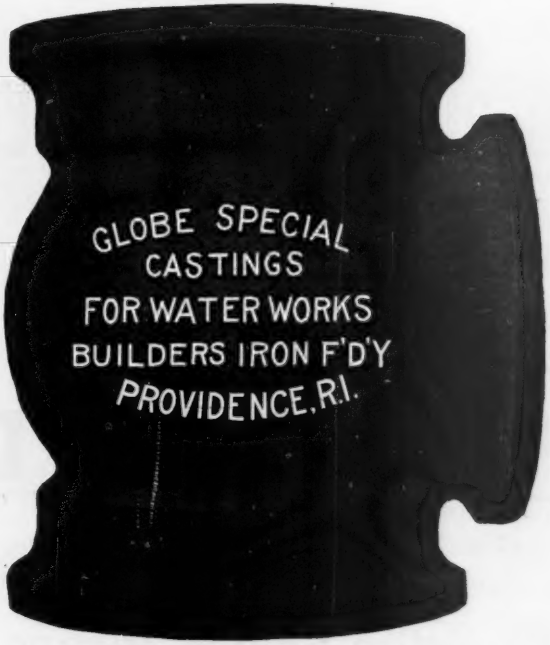

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